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OBJECTS AND METHODS OF INVESTIGATING CERTAIN PHYSICAL PROPERTIES OF SOILS.*

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INTRODUCTION.

THE physical properties of soils are recognized by plant physiologists to be of the greatest importance in plant economy. Even in the consideration of climatic conditions, it is now generally considered that for most economic plants the meteorological conditions of the soil hold equal rank with atmospheric conditions. A high temperature in the soil under favorable conditions promotes extensive root development; a high atmospheric temperature under equally favorable conditions favors a heavy growth of foliage. A deficiency in water content of either air or soil is attended with distress on the part of the plant. Finally, the leafy portion of the plant and the root system have been shown to be correlated in so many other ways that even without the experimental proofs mentioned above the great influence of soil conditions becomes at once apparent.

The peculiar characteristics displayed by many soils in their relation to plant life can thus be traced, in many instances, directly to certain physical properties of the soil. In the term "physical properties" as applied to soils, we here include also those properties which, in the case of the atmosphere above the soil, are commonly separated into a group known as "climatic conditions." In this broader definition we thus include the two more important soil conditions influenced by climate, namely, the temperature and the moisture content.

In considering the physical characteristics of the soil we must include also the soil atmosphere. By this term we designate the gases contained in the interstitial spaces of the soil, which are thus more or less separated from and to some extent independent of the atmosphere above. This soil atmosphere, particularly when inclosed to some extent by soil moisture, has been shown by King to be capable of modifying somewhat through barometric or temperature changes the distribution of water in the soil.

We thus see that, from a physical standpoint, the soil under field conditions may be divided into three parts, as follows: (1) The soil proper, consisting of the soil grains of various sizes, grouped in different ways, and made up of insoluble or difficultly soluble minerals; (2) the soil moisture, covering the soil grains, and containing in solution a varying amount of the soluble soil constituents; and, (3) the soil atmosphere, differing from air in composition to some extent, and usually saturated with water vapor.

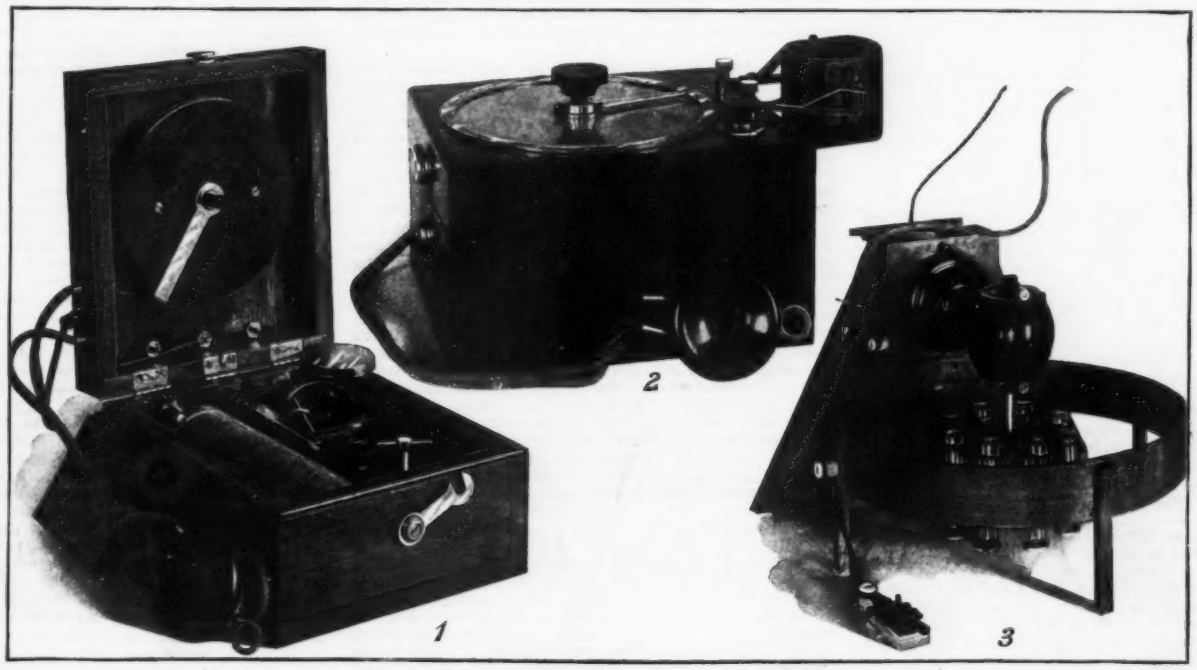


FIG. 1.—APPARATUS FOR INVESTIGATING PHYSICAL PROPERTIES OF SOILS.

1. Interior of soil hygrometer, used in investigating the water content of soils in the field; 2, electrical apparatus, used in determining the soluble salt content of soils and irrigation waters; 3, centrifugal apparatus, used in the mechanical analysis of soils.

PHYSICAL PROPERTIES PECULIAR TO THE SOIL GRAINS.

Soil Texture.—The two more important physical properties of a soil considered from the standpoint of the first class are texture and structure. Following previous usage of these words, we shall define "texture" to represent the relative sizes of the soil grains, while "structure" will be taken to represent the arrangement of these grains under field conditions. These terms at the present time have only a relative meaning, that is to say, there is no fixed scale for measuring or expressing either texture or structure, such as we have for temperature. In the case of structure we can at present only say that one soil has a closer or a more open structure than another. In a similar manner we say that one soil has a finer texture than another. A more specific statement of texture can, however, be made by the use of the results obtained by mechanical analysis.

The mechanical analysis of a soil consists in separating the soil grains into groups according to size, and in determining the relative amounts of the different groups, which together constitute the soil. Such an examination gives the most reliable means at present available for the comparison and classification of soils, since it is practically free from personal bias and errors of judgment.

In some cases a mechanical analysis fails to give proper indication of important and distinctive characteristics, since it deals only with the size of the grains and not with their arrangement or other physical properties. Beyond question, however, plant development is greatly influenced by the texture of the soil. Whether the texture has a direct influence or whether the effect is due entirely to the change in the water content and other physical properties is not definitely known, and for the present is of secondary importance. The unmistakable relation between the texture of the soil and the character of the crop grown is the important point. This relation makes possible the classification and mapping of soils and the correlation of soils of widely separated areas.*

The great importance of a thorough knowledge of the texture of soils is well illustrated in the recent work of the department relating to the growing of tobacco in the Connecticut Valley. It was observed by Professor Whitney that certain soil areas of the Connecticut Valley were practically identical as regards texture and water content with certain areas in Florida upon which the finest of cigar wrappers are being grown from Sumatra seed. Experiments were accordingly made on one of the Connecticut areas, using the same seed and methods of cultivation and curing employed in Florida, with the most satisfactory results. Should the more extensive experiments now in progress support the earlier work,

FIG. 2.—SOIL HYGROMETER AS USED IN THE FIELD, WITH SECTIONAL VIEW OF THE SOIL, TO SHOW CARBON ELECTRODES AND TEMPERATURE CELL.

* From the Yearbook, United States Department of Agriculture, 1900.

* Striking examples of the relation between the texture of the soil and the character of the product may be found in "Tobacco Soils of the United States," by Prof. Milton Whitney, Bulletin No. 11, Division of Soils, 1897.

as there is every reason to expect, the result will be to increase greatly the area adapted to the growing of the finest quality of cigar wrappers known, and there will be grown in this country tobacco now imported to the amount of $6,000,000 annually.

This case serves also to emphasize the necessity and importance of surveying important agricultural areas and mapping the various types of soils found, since it is evident that the profitable production of some specialized crop on a given type of soil can be satisfactorily extended to other similar areas only when the location and boundaries of these areas are accurately known.

MECHANICAL ANALYSIS OF SOILS.

Centrifugal Method.—The mechanical analysis of soils is carried on in this laboratory by what may be called the centrifugal method. Five grammes of oven-dried soil, previously passed through a 2-millimeter sieve, are shaken for several hours with about 200 cubic centimeters of water until the sand grains are free from clay. The sample is then transferred to a centrifugal machine of the form illustrated in Fig. 1, and the larger soil grains are thrown down by centrifugal motion to the bottom of the tube, leaving the clay in suspension in the water. The "clay water" is then carefully decanted, the material at the bottom of the tube brought in suspension once more by a jet of distilled water under pressure, and the process repeated until all the clay is removed. This is determined by examining the residue in the tube microscopically, using an eyepiece micrometer, for particles belonging to the clay group.

The apparatus shown in Fig. 1, (3), is arranged for analyzing eight samples of soil at one time, one sample in each tube. The centrifugal framework is suspended from the axis of a one-eighth horse power electric motor, which is provided with a rheostat for securing different speeds and a reversing switch for stopping quickly.

It is not necessary to use the centrifugal apparatus for the purpose of separating the "silt" group, since the sands settle quite rapidly, leaving the silts alone suspended in the water, which is then decanted as before. The material remaining in the tubes constitutes the sands, which are dried, and then properly graded by means of sieves and bolting cloth.

The "clay" and "silt" groups, which are still in contact with the water with which the separations were made, are evaporated to dryness in metal dishes on a dry plate, then transferred to small platinum dishes, and ignited to remove organic matter. Since during the ignition any calcium and magnesium carbonates present are reduced to oxides, it is necessary to convert the oxides into carbonates again before weighing. This is done by treating for two hours the samples in the presence of water with carbon dioxide under a pressure of about 50 pounds per square inch. The separations are again evaporated to dryness, heated to 110 deg. C., and finally weighed.

The amount of organic matter could be determined indirectly from the original weight of the sample minus the combined weights of all the separations. To check the accuracy of the work, however, a direct determination of the loss on ignition is made on another 5-gramme sample, which is ignited and treated with carbon dioxide as before; or the separations may be weighed before ignition and after ignition and treatment with carbon dioxide, the sum of the losses representing the organic matter in the sample used.

The manner in which the soil grains are grouped, together with their conventional names, is given in the following form. All of these separations are used directly as a basis for the classification of soils:

	Diameter (millimeters).	Conventional Names.
(1)	2—1	Fine gravel
(2)	1—0.5	Coarse sand
(3)	0.5—0.25	Medium sand
(4)	0.25—0.1	Fine sand
(5)	0.1—0.05	Very fine sand
(6)	0.05 —0.005	Silt
(7)	0.005—0.000	Clay
(8)	Soluble salts	
(9)	Loss on ignition	

In case a soil contains gravel (grains larger than 2 millimeters in diameter), the percentage amount of the coarser material is determined by a sieve separation on a large sample of 500 grammes or more.*

Soil Structure.—"Structure," as previously indicated, is a term used in soil physics to describe the arrangement of the soil grains. The conception is a somewhat vague one, since we have to deal in practice not with soil particles of any definite shape and size, but with particles in greatly varied forms and sizes, and consequently capable of innumerable configurations or arrangements. Some conception of what is meant by a change in structure may be gained by imagining the arrangement of the grains to be so changed as to change the mean size of the interstitial spaces. The subject is of great importance, but has not as yet been successfully attacked. About the only method available at present for investigating structure is the indirect one of determining the relative rates of flow of air or water through the interstitial spaces of the soil. This method answers fairly well when we are always dealing with the same soil; it fails completely when we attempt to compare two soils, on account of the difference in the texture.

WATER CONTENT OF SOILS.

The absolute dependence of economic plants upon a proper supply of soil moisture is a matter of common observation. In regions where the water supply is scanty or erratic, the proper conservation of the soil moisture becomes a problem of the greatest importance. This fact has led many soil investigators to make more or less elaborate investigations of the conditions favorable to moisture conservation. Another important branch of the subject is the determination of the normal water content of soil types, which has already been mentioned in connection with the investigations on tobacco soils, as being one of the methods of recognizing similar soil formations. In all experiments of this kind it is of course necessary to determine from time to time the amount of moisture present in the soil.

Gravimetric Method of Moisture Determination.—The water content of the soil may be determined in two radically different ways. The simpler method, and the one best adapted to a few determinations, may be called the gravimetric method. It consists simply in determining the weight of the moist sample, then drying it at 180 deg. C., weighing it again, and computing the loss in weight, which represents the water, as a percentage of the weight of the dry soil. This method is simple and direct, and can easily be carried out by anyone possessing scales capable of weighing to 1 part in 200 with a load of 100 or 200 grammes. The only precautions to be observed are: (1) Prevent evaporation as much as possible before weighing; (2) dry thoroughly; and, (3) prevent the dry sample from taking up moisture from the air before the final weighing.

Electrical Method of Soil Moisture Determination.—When a large number of moisture determinations have to be made in connection with field experiments, the labor involved is very great. In such cases the electrical method devised in the Division of Soils is of service. This method depends upon the principle that the resistance offered to the passage of an electric current from one carbon plate to another buried in the soil depends upon the amount of moisture present in the soil between the carbon plates or electrodes. This resistance is measured by means of a suitable instrument designed for this purpose, which is shown in Fig. 1, (1).

The electrical resistance of the soil between the carbon electrodes depends not only upon the amount of water present in the soil, but also upon the quantity of soluble salts dissolved in the water, and upon the temperature. For soils in which the amount of water-soluble material is not sufficiently great to interfere with plant development, field experiments appear to show that for any given water content the amount of salts in solution remains very approximately the same in any given soil. The determinations made by this method rest consequently upon the assumption that the salt content does not change independently of the moisture content. Wherever we have a translocation of salts, due to excessive evaporation or seepage, this assumption will not hold. In such cases the fact that a translocation of salts has taken place is shown by gravimetric moisture determinations, which should be occasionally made for this purpose; and if the departure from previous conditions is not great, the error may be easily corrected.

The effect of the change in the soil resistance due to temperature is eliminated by comparing the soil resistance with the resistance of a small cell containing a solution whose electrical resistance changes with temperature at exactly the same rate as the soil resistance, and which is buried in the soil near the electrodes so as to possess always the same temperature as the soil.

The comparison of these resistances is made by the instrument shown in Fig. 1, (1), which is a modified form of the well-known Wheatstone bridge method of measuring electrical resistance. The soil resistance and the temperature-cell resistance occupy adjacent arms of the bridge, and any change in temperature affects both resistances to the same extent, and so does not disturb the reading of the instrument.

In Fig. 2 is shown the instrument as used in the field. A sectional view of the soil is also shown, with the carbon electrodes and temperature cell in place. Electrodes in distant plants may be connected with the instrument by means of overhead wires, so that all the measurements may, if desired, be made from some convenient central point.

The carbon electrode and temperature cell may be buried in the soil at the beginning of the season and remain undisturbed throughout the year. The moisture record obtained consequently deals with the variation in moisture content of the same portion of soil. This is one of the advantages of the method, since it has been shown that the moisture content of a seemingly uniform soil may vary as much as 4 per cent within an area of one square rod. Consequently, in order to obtain a consistent record of the change in water content, it is necessary to deal with the same sample of soil, which can only be done by this electrical method. Concordant results may of course be obtained by the gravimetric method, if the average of a sufficiently large number of samples is taken, but this involves a corresponding increase in the amount of work required.

A standardization or careful determination of the water content of the soil is necessary at the time the first reading of the instrument is made, in order to determine the relation between the instrument readings and the actual water content. The scale of the instrument is arranged on a decimal plan; so that when the relation mentioned above is once determined, the water content of the soil at any future time can be determined directly from the scale of the instrument, requiring only a slight mental calculation. The standardizations should be repeated from time to time in order to be sure that no change in the salt content has taken place.

We thus see that the electrical method has the advantage of working always with the same portion of soil and furnishes a direct and rapid method of determining the water content after having once been installed. It has the disadvantage of a liability to error in soils where a translocation of salts is apt to occur, and the cost of the instrument and the time involved in the installation and standardization would not justify its use when a few or only occasional determinations are required.*

TEMPERATURE OF SOILS.

The temperature of soils is another physical property that admits of exact measurement. The economic importance of such measurements is not, however, very great, since the temperature of soils under field conditions is not to any great extent under our control. Temperature investigations have shown that we can to some extent increase the warmth of the soil in the early spring by thorough drainage, since a part of the water is in this way removed and the amount of material which must be heated is lessened, and loss of heat due to surface evaporation is also decreased. The temperature of soils in midsummer can also be somewhat reduced by an efficient dust mulch, which is not a good heat conductor. Temperature investigations have also shown that the shade of the foliage serves to reduce the daily fluctuation of the soil temperature to a considerable extent, by protecting it from the direct rays of the sun and also by cutting down the heat lost at night.

Use of Mercury Thermometers.—Certain forms of mercury thermometers may be successfully used for measuring soil temperatures for short distances below the surface. The precaution must be taken to make the support of the thermometer of wood or other non-conducting material, otherwise the temperature of the thermometer bulb will be raised by conduction. The most important advances in this branch of thermometry are due to the investigations of Whitney and Marvin.* Mercury thermometers are not, however, well adapted for determining subsoil temperatures, and for surface work the stem of the thermometer is frequently in the way of tools and consequently liable to damage.

Electrical Thermometer and Its Uses.—The objections are overcome in the electrical resistance thermometer, which depends for its operation upon the principle that the electrical resistance of a pure metal is a function of the temperature. In using this instrument a small resistance coil of insulated iron wire inclosed in a leaden sheath is buried in the soil at the desired depth, and connected by insulated wires to the measuring instrument, which may be 50 feet or more away. The resistance of the iron resistance coil, which changes appreciably with change in temperature, is compared by means of the measuring instrument with the resistance of a "manganin" coil, which has a zero temperature coefficient for ordinary temperatures. Consequently, the increase or decrease in resistance of the iron coil may be found, and, knowing the change in resistance per degree, the temperature of the iron coil can at once be determined. For convenience, the instrument is graduated to give the temperature of the coil directly instead of its resistance; so that no calculations whatever are needed, the temperatures being read directly from the scale of the instrument.

This form of thermometer has proved a great convenience in measuring the temperature not only of soils, but also of greenhouses, tanks, and of bulks of tobacco during fermentation. It has the important advantage over any ordinary thermometer that the coil for measuring the temperature can be placed wherever desired, no matter how inaccessible the location might be to an ordinary thermometer, while the measuring instrument may be put in the office or any convenient place. Any number of coils may be read by one instrument, a change of a single connection being all that is necessary for reading each coil.†

ELECTRICAL METHOD OF DETERMINING SOLUBLE SALTS IN SOILS AND IRRIGATION WATERS.

The soluble salt content of a soil is a chemical rather than a physical property of soils, but since a physical method of determining the salt content is also employed in the Division of Soils, a consideration of this method will be in place.

The importance of investigations on the soluble salt content of soils and irrigation waters needs no emphasis with those who are familiar with conditions in the western part of the United States. The abundance of soluble material in the soil in many Western areas demands the greatest care in the use of water, otherwise the soluble constituents of the soil will collect in the lower lands through the seepage waters or else move upward into the surface soil through excessive evaporation, in either case injuring or even entirely preventing plant development.

Timely examinations have frequently resulted in the preservation of valuable tracts of irrigated land which would otherwise have inevitably been ruined by the methods of irrigation in vogue. Many cases of this kind could be cited, and they are, indeed, striking illustrations of the great economic importance of soil investigations. The remedial measures employed depend, of course, upon the existing conditions, but the solution of the problem in general is the use of underdrainage to prevent the water table from coming too near the surface, and the avoidance of irrigation water containing a dangerous amount of soluble salts.

It is highly important, therefore, to determine in such cases the amount and location of soluble material present in the soil, whether these soluble salts are being transported to or from any other soil, and whether the irrigation water applied carries sufficient material in solution to prevent ultimately the growth of economic plants.

These questions may all be answered by the determination of the soluble salt content of properly chosen samples from different portions of the area and at various depths below the surface. This determination may, of course, be made by chemical methods, but a much more rapid method is available when the total amount of salts only is required. We have seen in the discussion of the electrical method of moisture determination that the electrical resistance of the soil depends principally upon three things—moisture, salt content, and temperature. It is therefore evident that, if we can keep constant the moisture content and the temperature of a series of soil samples, we can determine their relative salt contents from their electrical resistances. This constitutes the basis of the electrical method of determining the salt content.

It is more convenient in actual field work to determine the variation in moisture and temperature than

* For a more detailed account of the centrifugal method of mechanical analysis, see "Some necessary modifications in the methods of mechanical analysis as applied to alkali soils," by Lyman J. Briggs, Report 64, U. S. Department of Agriculture, 1900.

* For a more detailed account of this method and the construction and operation of the instrument, see "Electrical Instruments for determining the moisture, temperature and soluble salt content of soils," by Lyman J. Briggs, Bulletin No. 15, Division of Soils, 1899. An extensive application of this method to the investigation of the water content of soils will be found in an article by Hays and Smith, Bulletin No. 68, Minnesota Experiment Station, 1900.

* Agricultural Science, Vol. VII, 1893.

† This instrument will be found fully described in Bulletin No. 15, Division of Soils, 1899, entitled "Electrical instruments for determining the moisture, temperature and soluble salt content of soils."

to attempt to maintain them constant. In actual practice, therefore, the temperature and moisture content are noted, and the observed electrical resistance is afterward reduced to uniform moisture and temperature conditions from data obtained by laboratory determinations.

The resistance of the sample is measured in the field by means of the apparatus shown in Fig. 1 (2). Distilled water is slowly added to the sample under investigation until it is saturated—that is, until free water begins to appear. The saturated soil is then packed with a spatula into the small cell supported at the end of the instrument, the soil being struck off level with the top. This cell is made of hard rubber with two metal sides, and the instrument measures the resistance offered to the current in passing through the saturated soil from one metal plate to the other.

To interpret the field results an interpolation concentration-resistance curve is prepared in the following way: A quantity of soil or soil crusts, representative of the soils under examination as far as the composition of the soluble salts is concerned, is leached with water and the seepage solution evaporated to dryness. From the solid salts thus obtained a series of solutions of different-known concentrations is prepared. The resistance of each solution is determined, and from these data a resistance-concentration curve is made.

In reducing the observed resistances obtained in the field we compute what the resistance would be if the cell were completely filled with the soil solution alone, the soil grains being removed. This can be readily determined if we know the weight of dry soil contained in the cell and the amount of water required to saturate it, both being definite laboratory determinations which have already been made for different soil types, and which apply to all the salt determinations in soils of any one type.

We now trace along on the diagram the vertical line corresponding to this resistance until it intersects the curve; and then tracing the horizontal line passing through the point of intersection until it meets the axis we can at once read off the concentration of the solution. A simple calculation suffices to give, if desired, the weight of salt in unit weight of soil. In the case of irrigation waters the process is similar, though more simple. A quantity of water is evaporated to dryness and from a known weight of soluble salts thus obtained a series of solutions of known concentration is prepared, from which a curve is constructed as before. A comparison of the observed resistance of the irrigation water at any time with the curve gives at once the amount of soluble salts present. In all cases the resistance must of course be reduced to the temperature for which the curve was constructed, which is readily done from tables.

It will at once be seen that if a number of determinations are to be made, this method, depending upon the electrical resistance of the solution, is much more rapid than any chemical method for the determination of the total soluble salts. Two men can, by using this method, take from 60 to 100 samples of soil and determine the salt content of each in a working day. This method does not, of course, tell us the composition of the salts, for which we are dependent on chemical methods; but it does give at once the total amount of soluble salts present, with an accuracy amply sufficient for field work.*

OTHER PHYSICAL PROPERTIES OF SOILS.

Space forbids more than a passing mention of certain other physical properties of soils which are of great interest and importance. The flocculation of clay particles has a direct bearing upon the tilth of a soil, as well as upon the rate of the capillary movement of water, and a knowledge of the conditions governing flocculation is consequently of direct economic importance. Carbonate of lime, gypsum, and certain other salts, especially the alums, are particularly active in flocculating the clay. This is undoubtedly one reason why the application of lime is beneficial to some heavy soils, since the aggregates formed possess many of the characteristics of a solid particle of the same diameter, and the soil in drying presents a loose, crumbly structure. Ammonia and sodium carbonate or "black alkali," on the other hand, break down any aggregates which have been formed, and thus have the effect of "puddling" the soil, which dries into a hard, compact mass. Concentrated solutions of all salts, however, produce more or less flocculation. Aside from the action of salts, comparatively little is known regarding the conditions controlling flocculation, and the subject deserves thorough investigation.

Finely divided solids, such as, for example, the minerals constituting the soil, when brought into contact with a solution, have the property of removing a portion of the dissolved substance from solution and concentrating it upon the surface of the solid. This phenomenon is known as absorption, and is undoubtedly of great importance from an economic standpoint, since it helps to retain the soluble plant food in the soil which would otherwise be soon carried away in the drainage waters. The concentration of the solution immediately at the surface of the solid is, so to speak, much greater than in other portions of the solution, and the absorbed portion of the dissolved substance is not free to move like the remainder. Thin films of carbon dioxide and other gases with which the soil is in contact are also condensed on the surface of the soil grains in a manner very similar to substances in solution.

The obstorbed portion of the dissolved substance is, of course, in equilibrium with the solution, and the amount absorbed consequently varies with concentration and the temperature. These relations are of much importance, and are now being investigated, together with the relative absorption of different salts.

The translocation of salts and the capillary movement of water† constitute other important soil problems, regarding which we have considerable experimental knowledge, but which, like those already discussed, must be more completely investigated before many of the great field problems that are daily presented can be completely solved.

* A more complete description of this instrument and its operation may be found in Bulletin No. 15, Division of Soils, 1899.

† A discussion of this last-named subject by the writer will be found in "The mechanics of soil moisture," Bulletin No. 10, Division of Soils, 1898. A less technical discussion may also be found in an article in the Yearbook for 1898 on "The movement and retention of water in soils."

AMMONIUM AMALGAM.

COEHN (Ztschr. Anorg. Chem., xxv., 430) has recently published the results of an investigation on this subject, and these are given here in abstract. The increase in volume which takes place during the formation of ammonium amalgam has been used as an argument in favor of the view that ammonia and hydrogen are absorbed as such by the mercury, and that a distinct substance, ammonium, is not in combination with the mercury. In opposition to this view it has been shown that the volumes of the gases evolved bear to each other the ratio $NH_3:H = 2:1$; and, further, that neither ammonia nor hydrogen is absorbed by mercury.

An attempt has been made by Landolt to obtain some experimental evidence of the metallic nature of the substance ammonium, contained in the amalgam, by bringing the freshly prepared amalgam into solutions of salts of the heavy metals and determining whether, under these conditions, ammonium can replace these metals from their salts. Treated in this manner, neither copper, nor silver, nor iron, could be precipitated. This, he says, is opposed to the view that ammonium has a metallic nature.

Le Blanc thought it possible that the ammonium might be so unstable that it would not have the power to replace metals, but would decompose into ammonia and hydrogen as soon as liberated from the amalgam.

He attempted to solve the problem as to the nature of the substance contained in the amalgam by electrolyzing solutions of ammonium salts, using a mercury cathode, and comparing the polarization on the one hand with that which results when an alkali amalgam is formed in this way, and, on the other, with that which is obtained when hydrogen alone is developed on the cathode. If the value found approximates that obtained by electrolyzing an alkali salt it would argue in favor of the existence of ammonium in the amalgam. If, on the contrary, it approached the value when hydrogen alone is developed on the cathode it would argue against the existence of ammonium. His results pointed to the existence of ammonium in the amalgam.

It has been shown that in addition to the tension at which the development of hydrogen takes place in a reversible manner, as in platinized platinum, there is a characteristic tension for each metal. Thus, the reversible evolution of hydrogen, obtained by discharge of hydrogen on a mercury cathode with continuous current, took place at 15.2 volts. If an alkali metal is in solution, using the mercury cathode, there is obtained in addition to the point at 15.2 volts another point beneath this, which changes with the nature of the alkali metal, and is, therefore, characteristic of the latter, and corresponds to the formation of the amalgam. This took place with ammonium at 1.24 volts, and is therefore completely analogous to the case of the alkali metals.

The only argument against the metallic nature of ammonium still remaining was that of Landolt, and it is this which Coehn has tested in a different manner and under different conditions. The ammonium amalgam was freshly prepared by electrolysis and dropped into a solution containing copper sulphate. A platinum wire which was connected through a galvanometer with a platinum plate suspended in the solution projected upward through the bottom of the vessel. The amalgam came in contact with the platinum point, and the action of the element, if copper is replaced, would be to deposit copper on the plate, with the simultaneous passage of a current through the galvanometer. It was found that no copper was deposited, and only a weak current of momentary duration passed through the galvanometer. To test whether Le Blanc was correct in supposing that ammonium was too unstable to replace other metals, he prepared the amalgam so that it would be more stable by electrolysis of ammonium salts, cooled down nearly to 0 degrees.

It was found that the amalgam thus prepared did not show the tendency to swell up unless it was warmed, and it has quite a metallic appearance. When ammonium amalgam, thus prepared, was brought into a solution of copper sulphate, cooled to about the same temperature, the formation of copper amalgam could be seen with the naked eye. Observing these precautions and using the apparatus mentioned above, separation of copper on the plate took place at once.

That the replacement is not due to the hydrogen developed by the decomposition of the ammonium is shown by the fact that metals like cadmium, and especially zinc, which are not reduced by hydrogen, can be precipitated in this way from solutions of their salts.

The author has thus removed the last experimental evidence against the metallic nature of ammonium.—American Chemical Journal.

A NEW METHOD OF DILUTING ACETYLENE.

IT is fairly well recognized that most of the methods which have been proposed for burning diluted acetylene, except, of course, the acetylene oil gas of the German railways, have proved practically useless. This is due to the fact that either the diluent has disproportionately reduced the illuminating power of the whole product, or else that in those places where acetylene is most calculated to be serviceable to the inhabitants there are no facilities at hand for making any desirable kind of diluent. One of the most recent proposals, offered by Albrecht Heil, of Frankfurt am Main, is to copy the process adopted in manufacturing "air" gas, leading acetylene through light petroleum spirit or gasoline, so as to mix it with the vapors of that extremely volatile substance. The acetylene is generated and purified in the usual fashion, and is either led through a vessel filled with porous blocks kept constantly moist with the gasoline, or it is made to bubble through a certain volume of the liquid itself. Various advantages are said to be obtained by this process; the diluent is a combustible gas of high illuminating and calorific power, therefore the duty of the acetylene is not unduly decreased. The explosibility, which presumably means the range of explosive limits, of the diluted gas, is lowered. There is no likelihood of adding air to the acetylene during the dilution. Introduction of the petroleum vapor "permits" the acetylene to be used in an incandescent burner without blackening and ruining the mantles, and the burners work smoothly without showing any tendency to fire back to the jet. This claim, however, is in some respects exaggerated; that is to say, ordinary acetylene will work in a specially designed incandescent burner, and does not fire back unless the pressure is too low, or unless attempts are made to turn the burner down. We do not care for acetylene incandescent burners, as we remarked on a previous occasion; but justice compels us to say that our dislike was based on the trouble given by the mantles, rather than by the burners themselves, which seemed quite efficient. We have never found mantles to be colored black; they tend rather to break and crack very quickly, probably because traces of phosphorus still escape some systems of purification, and act prejudicially upon the rare oxides. The intensity of the explosions of this acetylene diluted with petroleum vapor is also stated to be lower, so that the mixture ignites more slowly and gently than neat acetylene in a gas engine cylinder.

If further experience should bear out these claims, the process of diluting acetylene in this fashion is one that could easily be employed by every country consumer. In all other methods of dilution more or less complicated, and sometimes power-consuming, plant is necessary, even when the second gas happens to be available or readily prepared. Here all that is needed is a special vessel following the purifier, containing no moving parts, and requiring no regular attention. By suitably arranging its dimensions, or the supply of gasoline entering it, a uniform amount of petroleum vapor ought to be added to the acetylene automatically, which would burn satisfactorily in luminous or incandescent burner, or, if desired, in boiling and warming stove. The process would not be very expensive to use, since the duty of incandescent acetylene, even diluted in this manner, is rather more than twice that of the luminous gas.—The Engineer.

THE DENSITY AND MOLECULAR WEIGHT OF OZONE.

SINCE Soret's (Liebig's Ann. Chem., cxxxviii., 145; and Supplement, V., 148) celebrated work on the density and molecular weight of ozone, carried out more than thirty years ago, no work has been done on this subject until Ladenburg (Ber. d. Chem. Ges., xxxi., 2508) took it up in 1898. Soret worked with a mixture of ozone and oxygen containing only 5 per cent of ozone, and hence Ladenburg deemed it important to re-determine these values, using purer ozone.

The ozone which he used was generated in a Siemens ozonizer, whereby a mixture of ozone and oxygen was obtained, containing 8 to 9 per cent of the former, which could be easily liquefied in liquid air. The author liquefied such a mixture by means of liquid air, and then allowed the mixture to boil until most of the oxygen had boiled off. A new mixture of liquid ozone and oxygen was added to the residue, and again the oxygen was allowed to boil off. By repeating this operation several times he succeeded in obtaining 2 to 3 c.c. of a blackish-blue, non-transparent liquid. He determined the density of the gas obtained when this liquid was vaporized and also the percentage of ozone in it. The density was determined by measuring the time of escape of the gas from a Schilling's apparatus, and comparing it with the time of escape of pure oxygen from the same apparatus. The apparatus had been previously tested with pure oxygen and nitrogen, and was found to give very satisfactory results.

Ladenburg thus found that the gas under investigation required 430 seconds to escape, while pure oxygen required 367 4-10 seconds. Hence, the density of the gas was 1.3698, that of oxygen being 1. The percentage of ozone in the gas was determined by titrating the iodine liberated from a solution of potassium iodide by a known volume of the gas. It was thus found that the gas contained 86.16 per cent by weight of ozone. From these data the density of pure ozone was calculated to be 1.456, that of oxygen being 1, while theoretically it should be 1.5.

Soon after the publication of these results Ladenburg (Ber., xxxi., 2830) published a note in which he made a correction. In the calculations by which the above results were obtained, he really assumed the molecular weight of ozone to be 48, while this is what he was trying to prove. So he deduced two algebraic equations, which, when solved, gave him 84.4 per cent by weight as the percentage of ozone in his mixture of ozone and oxygen, and 1.469 as the density of pure ozone.

Shortly after this Staedel (Ber., xxxi., 3143) and Gröger (Ber., xxxi., 3174) published, at about the same time, criticisms of Ladenburg's work, in which their chief objection was that it is impossible to calculate the density of pure ozone when the density of a mixture of oxygen and ozone and the amount of iodine liberated from potassium iodide only are known. Staedel claimed that Ladenburg assumed ozone to be O_3, and that in one of his equations he assumed the action of ozone on potassium iodide to consist in one atom of the oxygen in ozone liberating two atoms of iodine from the potassium iodide—an assumption which he had no right to make, since he was trying to determine whether ozone is O_3. Gröger expressed the belief that it would be possible to determine the density of ozone only when some absorbent was used which would absorb the ozone entirely without leaving behind a volume of oxygen equal to the volume of ozone started with.

In answering these two criticisms Ladenburg (Ber., xxxii., 221) agreed with Staedel and Gröger that the molecular weight of ozone cannot be determined from the density of a mixture of ozone and oxygen and the amount of iodine liberated by such a mixture, but he did not agree that this fact detracted from the value of his results.

He again called attention to the fact that the ozone prepared by him was nearly pure. After the oxygen

had boiled off at —186 deg. from the liquid mixture of ozone and oxygen, the thermometer rose 60 deg. without any gas being evolved. The determination of the density of his ozone, which contained a little oxygen, gave the value 1.3698, which corresponds to a molecular weight of 43.8. This showed conclusively, Ladenburg thought, that the molecule of ozone is O_3. If, for instance, it were O_4, there would be an error in his results of over 50 per cent, and the conclusion would follow that his ozone contained 60 per cent of oxygen, for which there was not the slightest evidence.

The determination of iodine liberated from potassium iodide was made merely to ascertain the percentage of ozone in his mixture, which was found to be 84.4 per cent. This value was then used in correcting the density found to that of pure ozone, and 1.469 was the result obtained, which corresponds to a molecular weight of 47.

Quite recently Brunck (Ber., xxxiii., 1832), in an article on the quantitative determination of ozone, referred again to the apparently inadequate proof of Ladenburg that ozone has the molecular weight 48. This reference called forth another reply from Ladenburg (Ber., xxxiii., 2282), in which he used substantially the same argument which he used against Staedel and Gröger, and further he criticises some of the results of Brunck regarding the liberation of iodine from potassium iodide in acid solution. Brunck (Ber., xxxiii., 2999) answered these criticisms in a later paper.—American Chemical Journal, xxv., No. 5.

ERYSIMIN.

THIS is a glucoside recently isolated from the seeds of the Cruciferous plant, *Erysimum aureum*. The discoverers, Schlagdenhauffen and Reeb, state that it is an amorphous pale yellow compound, soluble in any proportion in water and alcohol, but insoluble in ether, chloroform, benzol, and carbon disulphide. It is slightly hygroscopic, melts at 190 degrees C., and has the formula $C_7H_{12}O_7$. Potassium myronate is not present in the seeds. Erysimin is a powerful heart poison.—Pharm Centralh., 42, 94.

ENGRAVING MACHINE.

NEARLY ten years ago, says Engineering, we published an account of an engraving machine, made by Messrs. Taylor, Taylor & Hobson, of Stoughton Street Works, Leicester. Since that time very great improvements have been made in the machine, which is now used by leading brass and general engravers; by engineers and makers of hardware; in making stamps, dies, and original stamp models for printing; molds for glass, rubber, soaps, etc., and for engraving seals. It will, therefore, interest our readers to know what form the machine has taken after the various improvements which have been made in it. This they will see from the perspective view given in Fig. 1, while they will gather the details of construction from the remaining figures.

As regards the general principle, there is no novelty; it is in the method of carrying the principle into effect that the new features are to be sought. The engraving is done with a rotary cutter, the shape of which varies according to the character of the letter or of the work which is to be cut. This cutter is not stationary, but can be moved to and fro to follow the outline of the letters or other device, while at the same time it is kept in rotation by a gut band. The movement of the cutter is determined by a style which the operator moves over an enlarged copy. Between the style and the cutter there is interposed a pantograph by which the motion is reduced, the proportion of the arms of the pantograph being such that the work may be one-third, or any less proportion, of the copy. By removing the pantograph, work can be executed of the same size as the copy itself.

Referring to the engravings, Fig. 1 shows a general view of the machine, Fig. 2 shows a table for attachment of circular work, and Fig. 3 a plant of the pantograph. In this latter two copy-holder can be seen. Upon it can be clamped the copy, which may either be a specially prepared plate, or else standard metal copy types, fixed in grooves, and arranged to spell any desired wording, the spaces being provided for by blanks. The style is fixed in the end of the long arm, *L*, and stands above the copy. The members of the pantograph are *L*, *J*, *F*, and *B*, the cutter frame slider, *H*, being clamped to the bar, *F*, on which there is engraved a scale by which the bars can be set to give the desired degree of reduction from the copy. For this purpose the bolts of the sliders, *D* and *E*, are loosened, and the sliders are set so that their index edges coincide with the marks indicating the desired scale of reduction. Tightening pulleys, *A* and *C*, are provided to keep the band taut, in spite of the movement of the cutter spindle to and fro as it follows the outlines of the letters.

Figs. 4 and 5 show the cutter spindle and the means of feeding it to its work. The spindle, *S*, has a pulley or wharve at its lower end, the pulley being recessed so that the center pressure of the band falls within the lower bearing of the spindle. This bearing is conical, while the upper bearing is a deeply recessed "center," which can be easily set to take up all shake, and yet to leave the spindle quite free to revolve. The cutter spindle is fed down to give the required depth of

FIG 1.

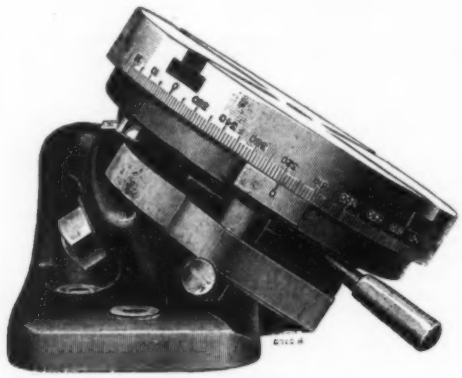


FIG 2.

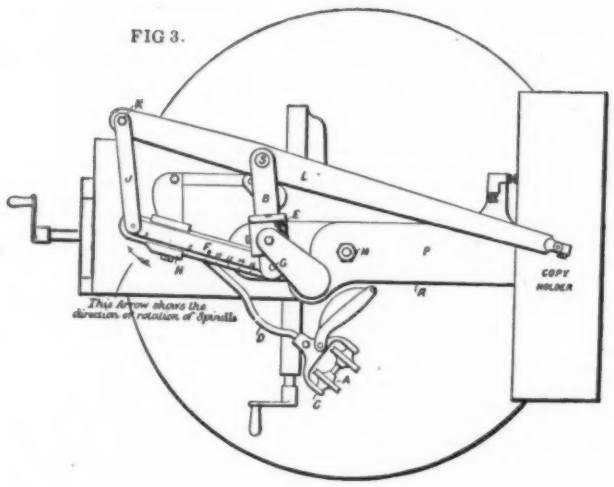


FIG 3.

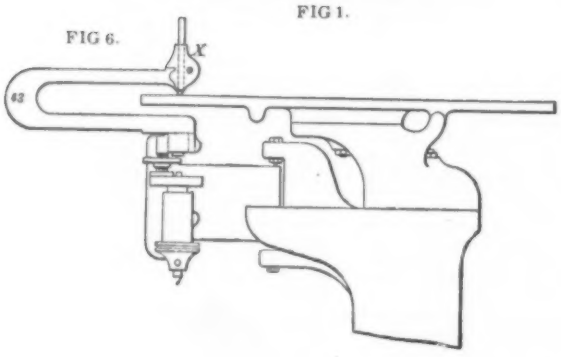


FIG 6.

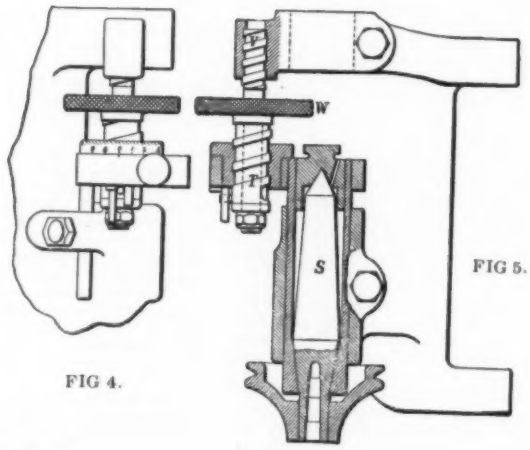


FIG 5.

FIG 4.

ENGRAVING MACHINE.

In two ways. The stop rod shown in Fig. 4 can be set, and the nut in which the screw, *T*, revolves fed down on to it, or the adjustment may be made by the engraved scale round the nut. The screw, *T*, is bored through, and within it there is a spindle, the spindle and the screw being clamped together by a washer and nuts in such a way that there is sufficient friction to turn the screw when the spindle is rotated, but yet not enough to prevent the spindle slipping when the screw comes against a stop. The screw has only a small range of motion, as it has a small projecting pin whose traverse is determined by two vertical pins (Fig. 4). When the graduated scale is set to zero, as in Fig. 4, the cutter may be moved up and down by the milled wheel, *W*, and its position fixed by the stop-rod, as already explained. Instead of feeding the cutter in this way to a fixed stop, the graduated scale may be used to cause the cutter to penetrate any constant distance, measured from the surface of the work. The divisions of the scale indicate hundredths of an inch. The scale is set to the required depth; the nuts at the

bottom of the spindle are tightened to make the spindle turn stiffly in the screw, *T*. The wheel, *W*, is then turned until the cutter just touches the surface of the work; then the wheel is turned backward until the pin projecting from the nut meets the stop-pin. This moves the cutter to the required depth.

Fig. 6 shows the pantograph removed, and the cutter spindle moved directly, the style being directly over a full-sized copy.

Figs. 7 to 9 show three forms of cutter, and Figs. 10 to 13 the methods of grinding them, Fig. 12 being an enlarged view to illustrate the backing off which affects the cutting edges. The grinding of the cutter is done by an emery, whose spindle (Fig. 13) fits in the cutter spindle (Fig. 5) when the cutter is removed. A grinding attachment (Figs. 1, 10, and 11) is provided for holding the cutter in relation to the emery wheel, each cutter being placed for grinding in a spindle (Fig. 10), which lies in two bearings in the attachment, *Z*. By aid of this attachment grinding becomes a perfectly easy operation, and cutters such as Figs. 7 to 9 can be kept in perfect condition with very little trouble.

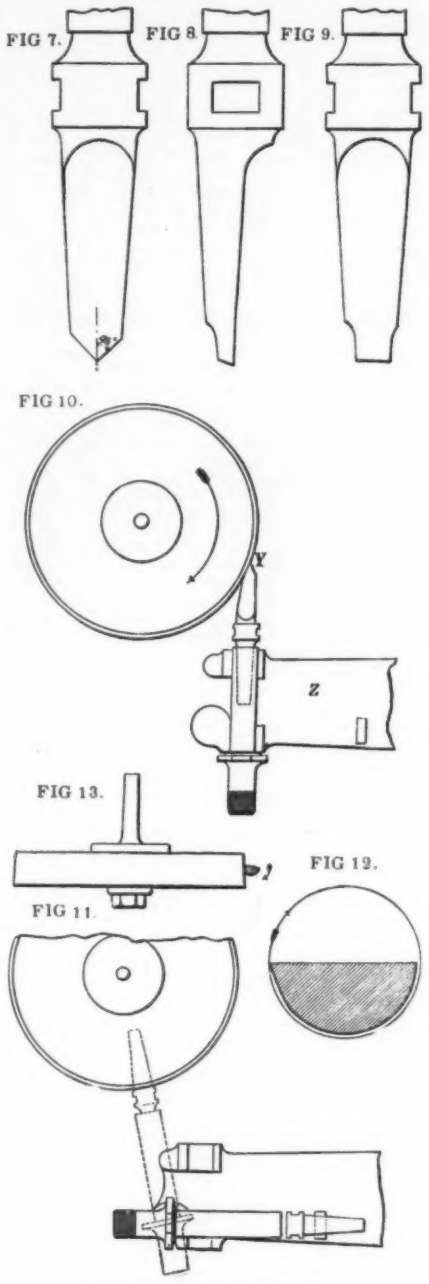
The circular attachment (Fig. 2) is intended to hold circular work, in the form of disks, cones, or cylinders, and to revolve it so as to present successive portions to the action of the engraving cutter. For this class of work it is necessary to bring the copy letters in turn to zero over the center hole of the copy-holder. The circular attachment is bolted to the slide-rest table, with the planed edge of its base close against the face of the vertical slide. In this position, on all reductions of the pantograph, the cutter is in line with the center of a circular disk, or above the axis of any cylinder held on the circular attachment, when the style is at the zero of the copy-holder. The spacing of letters on circular work may be decided by means of the paper index bands, on which lines may be ruled, and brought successively to coincide with the edge of the spring pawl; and for permanent work the paper band and its holder should be replaced by a circular disk of brass, 1/10 inch thick, and 4 inches in diameter, the edge of which may be provided with suitable notches to engage with the spring pawl. Like the faceplate of any lathe, this attachment can be provided with suitable chucks or holders for special work.

We have seen this instrument in operation and have also seen a large variety of work which it has done, and can testify to the ease and rapidity with which it is turned out, and also to its high quality. There are many purposes for which it is useful to engineers, especially in the cheap production of "directions" to be attached to cocks and the like, telling their uses, and the way in which they are to be manipulated. The machine will produce both lettering and designs either sunk or in relief, on metals and other materials.

INTERLOCKING GEAR FOR SUPERHEATER VALVES.

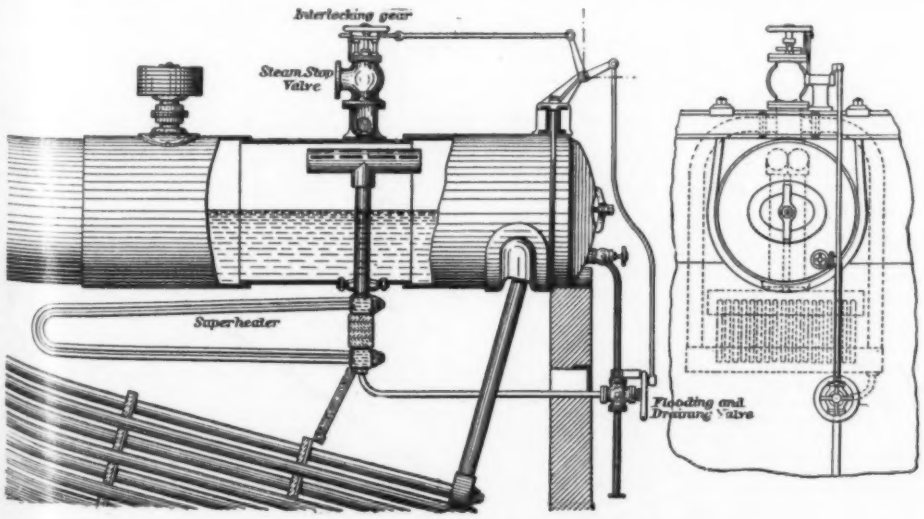
In connection with the use of superheaters upon steam boilers there is an element of care required upon the part of the fireman or attendant regarding the manner in which the valves connected with the superheater and the steam pipe main are operated.

In most superheaters it is necessary, when steam is being raised and the main stop valve of course closed, to admit water into the superheater tubes to prevent their being burnt. It is also necessary that this water shall be drained off from the superheater before the main steam valve is opened, otherwise there is a risk that the water which has not been completely evaporated into steam within the superheater will be forced out into the main steam pipe under the pressure of the steam in the boiler drum. It is evident from the illustration how this may occur, since the superheater receives its steam at the top, and delivers it from the bottom into the main steam pipe through the pipes shown dotted in the end elevation. To insure that this condition shall not arise, Lovell & Co., of 56 Chancery Lane, London, have patented an interlocking gear, and have fitted it to the boilers of the Reading Electric Supply Company, Limited. Our illustrations show the application of the gear to a Babcock & Wilcox boiler, its object being to prevent the main steam valve being opened while water is either in the superheater or while the drain cock is open for draining the water out of it. The simplest form of application is that in which a circular rack or ratchet is cast upon the underside of the main stop valve wheel. The flooding and draining valve hand wheel has connected to it a rod, which by a bell-crank lever moves a locking bar sliding in an inclosed casing, so as to raise the weighted end of a pivoted pawl, which engages and disengages with the ratchet on the stop-valve wheel. In the draining position of the combined flooding and draining valve the pawl is in contact with the teeth on the hand wheel, and this position is maintained during the whole of the movement of the hand wheel on the draining valve, except that when the draining valve is closed after it has moved in the direction, first to open



ENGRAVING MACHINE.

the flooding valve, then to drain, and, finally, to close it. The locking bar has a slot within it that is provided with a projection at one part so as to lift the pawl out of contact with the ratchet, the weighted end of the pawl sliding on the top of the locking-bar groove while the pawl is out of contact. The stop-valve wheel is free to be turned in the direction to close the valve at any time, but cannot be turned to open the valve except when the pawl is out of contact, the pawl being only out of contact when the flooding valve wheel is carried to its closed position. To prevent the flooding valve, or three-way cock generally used, from being moved in the wrong direction a ratchet and pawl is arranged in connection with the valve spindle, and to prevent the pawl on the hand wheel of the stop valve from being tampered with, it is pivoted and mounted in an inclosed casing, as shown.—The Engineer.



THE LOVELL INTERLOCKING GEAR.

A CENTURY OF CIVIL ENGINEERING.*

THE century which has just passed, the nineteenth of the Christian era, is distinguished from any of the preceding hundred-year periods in the world's history by the advances made in the co-operation of investigators in numerous branches of science in the formulation of doctrines regarding the nature and co-ordination of natural phenomena, which stand the test of experiment and calculation, thus leading to a nearer approximation to the understanding of the laws which govern such phenomena, and so to the development into a profession of the "Art of directing the great sources of power in Nature for the use and convenience of Man," which Art is entitled Civil Engineering. This definition is itself one of the most noteworthy products of the Nineteenth Century, and a study of the sequence of events and reasoning which led to its formulation is not without interest.

Ever since man became endowed with consciousness and the power of reasoning, he has been striving to solve the problems of the physical world around him in which he perceived matter in motion, which was evidenced to his senses by sight and touch, by sound and taste and smell, but which was devoid of sentience, so far as he could discover. He observed at once that by its different manifestations his physical comfort was materially affected, and it did not take long for him to learn that certain sequences of sensation, of one sort or another, followed certain manifestations occurring singly or in combination, and then that the order of many such manifestations could be controlled by him at will, while that of multitudes of others could not be so controlled at first, their methods and causes not being appreciable by his unassisted senses.

But until about three hundred years ago there does not seem to have been any systematic and well-directed effort to investigate the reasons why material changes occurred naturally, or how certain changes could be artificially produced with certainty.

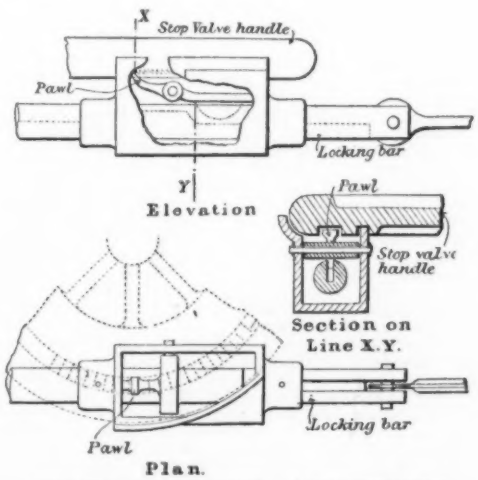
To discover the sequence of natural events is first of all an empirical task: facts must be observed systematically, and recorded, and then their combinations reasoned upon. Hypotheses can then be formed as to the probable effects of slightly different collocations and sequences of events, and these subjected to experiment and computation. An hypothesis cannot be established as a scientific fact until it has been verified by observation and also proved to be in accordance with mathematical laws. Tennyson's apothegm, that "knowledge comes, but wisdom lingers," is profoundly true.

Now, up to the beginning of the seventeenth century of the Christian era, there had been no organized physical experimentation, on a comprehensive scale, and intelligent reasoning therefrom. The speculations as to the laws of nature which had been made from time to time had been purely efforts of the imagination, and were unsustained by either practical demonstration or analytical reasoning. Various hypotheses had been framed, on insufficient or incorrect premises, and some of them had been so near the truth as actually to delay the progress of the truth, by the appearance of exactness in the reasoning from them, up to a certain point.

Really, the civil engineer had been practising his art and directing the forces of nature for the use and convenience of man, but without any conception of what those forces were, or how they acted, or of why he did anything, or what the result of it would be, unless he had done the same thing before in the same way. He did not know that the earth moved, and he had no idea why or at what rate a stone fell to the earth, or water ran down hill. He had no measure of heat or light, and used no power but that which the muscles of an animal produced. And yet he had built the Pyramids, the Parthenon and the Pantheon; had constructed aqueducts, canals and sewers; had regulated and maintained the rivers of China for thousands of years; and had just been recognized, on account of his labors in protecting the lowlands of Holland and the shores of Italian rivers from the encroachments of the water, as holding a distinct rank among the workers of the world.

Of the application of the forces of nature to aiding his labors, he seems to have been ignorant, except by the use of a flowing stream to turn a wheel. The earliest recorded application of this mode of producing power in England was in 1582, when Peter Moryss, a Hollander, procured from the City of London a

* President's address before the American Society of Civil Engineers at the Annual Convention at Niagara Falls, N. Y., June 25, 1901. From the Transactions of the Society.



DETAILS OF RATCHET ARRANGEMENT.

franchise for five hundred years for supplying water to the city by pumping from the Thames, using a wheel driven by the ebb and flow of the tide under London Bridge.

With the beginning of the seventeenth century, the world entered on a new era of science, theoretical and applied. The casual observation by a little child of the curious optical effect obtained by looking through two pieces of glass led to the invention of the telescope and the microscope, which disclosed to man objects beyond the reach of his unassisted vision. The swinging of a hanging lamp suggested to a thoughtful man the idea of an unseen force, and Galileo, by experiment and reasoning, discovered the law of terrestrial gravitation and first grasped the idea of force as a mechanical agent.

Turning his newly invented telescope upon the heavens, he was the first man in the world to witness the actual motion of the planets and their satellites, and to prove that they and the earth revolved about the sun, as Pythagoras had imagined two thousand years before, Copernicus had asserted a hundred years before, and his own contemporary, Kepler, had reasoned from the imperfect data then possessed, and had actually formulated the laws of their motion in forms which the science of our day confirms exactly. He was the first to conceive the theory of transverse strains in solids, but the facility of experimentation with fluids diverted his attention from more rigid bodies, and the fundamental principles of hydraulic science were established by him and by his pupils and immediate successors in the fascinating studies he had introduced.

To Galileo also is due the invention of the thermometer, which enabled definite measurement to be made of the mysterious phenomenon of heat which his great contemporary philosopher in England, Lord Bacon, conceived to be "an expansive undulatory motion in the particles of a body whereby they tend with some rapidity toward the circumference, and also a little upward." But Bacon was two hundred years in advance of the physicists, and the century was occupied almost exclusively in the elucidation of the laws of gravitation as exemplified in the action of fluids. For the study of liquids and their action demonstrated that they were, under certain conditions of temperature, transformed into invisible and elastic substances governed in general by the same laws, and also that there were all around other similar substances which could not be condensed into liquid in elastic form, but could be weighed by the barometer which Torricelli invented in 1643. And so the laws of gases came to be investigated and formulated by Mariotte, who, to aid him in his researches, invented the rain gage in 1677, and measured the liquids condensed from the atmosphere. The value of the data thus obtained, to the hydraulic engineer, was appreciated by the French engineers at once, and ever since 1681 records of the rainfall have been kept continuously at Paris, and the practice has gradually extended over the whole world. But it is worthy of note that fifty years after the invention of the rain gage, Belidor, in his magnificent treatise on Hydraulic Architecture (1728), the first compendium of engineering theory and practice, in treating of the sources of water supply for domestic use, did not mention the rain gage or the amount of rainfall, but dwelt on the divining rod as the recognized means of discovering subterranean streams of water.

The close of this century saw the final establishment of the law of gravitation by Newton's proof of its governing the whole material universe. And any review of the progress made during the century toward the understanding of the laws of nature would be incomplete without allusion to the two great steps taken in it toward the facilitating of mathematical computations, the invention of logarithms at the beginning of the century and of the calculus at its close.

That heat produced dynamic effects had been recognized for ages. That it destroyed some solids, that it converted others into different forms possessing entirely different properties, that it caused the dissipation and disappearance of liquids, were facts well established. That by its application to certain combinations of materials an explosive effect could be produced which overcame the force of gravity had been discovered three or four hundred years before when gunpowder was invented, but that a mechanical effect could be produced by the use of heat was not understood, and the nature of the phenomenon itself was not comprehended. It was looked upon by physicists as an "element" or primary form of matter, and in 1690 Stahl conceived the idea of "phlogiston," an elementary substance, invisible and inappreciable by the senses, which entered into the composition of combustible substances, and which, by the process of combustion, was separated from them and passed off in the form of corpuscles which, striking the sensory nerves, were perceived as heat. Sir Isaac Newton espoused this phlogiston hypothesis and also conceived that light was the product of certain corpuscles which were perceived by the optical nerves. The discussion of these hypotheses occupied the attention of the philosophers for the whole of the eighteenth century, and, in the meantime, the physicists were busy experimenting on the methods of utilizing the vapor into which heat converted water. By degrees, the steam engine was developed into a practical machine, capable of doing work which before could only be accomplished by animal labor, and the engineer availed himself of it in the handling of materials. But although the chemists had been striving for centuries to learn the composition of matter and the means of transforming and combining its several natural conditions, they had not, at the beginning of the nineteenth century, learned how to produce either heat or light, except by the aboriginal method of striking flint and steel together. In the lack of knowledge of the properties of these phenomena and the fact that they could be utilized on a large scale, there was no occasion for the devotion of any special class of men to their production and development. There were two other classes of phenomena which seemed as if they ought to be controlled by man, but the laws of which had so far eluded discovery—electricity and magnetism. So that, really, all that the civil engineer had to deal with was the force of gravity acting on such materials as the earth yielded him, in their natural state or as they could be modified by heat and manual labor.

But he had been making progress. In Italy, where the first application of science to consruction had been made, the study of the laws of hydraulic science had been constantly pursued, and those laws applied to the regulation of the rivers; in France, ever ready to grasp new ideas and to pursue their application to practical results, the principles of hydraulics had been studied and applied to the construction of great canals, and to the supply of water to Paris, where, in 1671, water was pumped by a water wheel driven by the current of the Seine and distributed through cast-iron pipes. In England, Hugh Myddelton had supplied London with water, and, in 1638, Nicholas Vermuyden had been called in from Holland to protect the lands along the River Ouse from overflow, a task so well accomplished that his work stood for a hundred years, and only failed then from lack of proper maintenance, the English having by that time apparently concluded that, as Dr. Franklin wrote in 1772, "rivers were unmanageable things," and, inspired by the success of the public waterways of France, turned their attention to the construction of canals and the improvement of harbors. Many important works of this class were built in England during the last half of the eighteenth century. The men by whom these works were constructed were not educated men or men experienced in scientific research. They certainly were men of great natural ability and good judgment, and capable of conceiving and executing great projects. One of the greatest of them, John Smeaton, who was the first Englishman to call himself a civil engineer, thus expressed his conception of the profession which he adorned:

"Civil engineers are a self-created set of men whose profession owes its origin not to power or influence, but to the best of all protection, the encouragement of a great and powerful nation, a nation become so from the industry and steadiness of its manufacturing workmen and their superior knowledge in practical chemistry, mechanics, natural philosophy and other useful accomplishments."

Smeaton was himself an investigator, but he is the only one of the civil engineers of Great Britain during the eighteenth century who strove to discover the laws which governed the operations of nature.

The most eminent civil engineer in England in the year 1800 was Thomas Telford, who was born in 1757. Beginning life as a mason, he developed an extraordinary faculty of generalization, combined with an intimate acquaintance with the details of workmanship in all the methods of construction known in those days. In the building of canals, highways, harbors, bridges and docks he displayed great grasp of the subject of the improvement of transportation facilities, as then existing, and great boldness of design and ingenuity in construction.

But it must be borne in mind that at that time the canal was considered the only possible mode of increasing facilities of transportation and reducing cost; no motive power except animal force was known, the metals were but little used in construction, and a framed structure adapted to bear heavy loads was unknown. As "an eminent mathematician," quoted in the Edinburgh Review in 1805, remarked:

"While we give ourselves infinite trouble to pursue investigations relating to the motions and masses of bodies which move at immeasurable distances from our planet, we have never thought of determining the forces necessary to prevent the roofs of our houses from falling on our heads."

It is related of Telford that when on one occasion he was consulted by a young man as to the advisability of his engaging in civil engineering, he said to him: "I have made all the canals and all the roads and all the harbors. I don't see what there is that you can expect to do."

His ideas regarding the training of the civil engineer are given at some length in his Personal Memoirs prepared shortly before his death.

"Youths of respectability and competent education who contemplate Civil Engineering as a profession, are seldom aware how far they ought to descend in order to found the basis for future elevation. Not only are the natural senses of seeing and feeling requisite in the examination of materials, but also the practiced eye, and the hand which has experience of the kind and qualities of stone, of lime, of iron, of timber, and even of earth, and of the effects of human ingenuity in applying and combining all these substances, is necessary for arriving at mastery in the profession. For how can a man give judicious directions unless he possesses personal knowledge of the details requisite to effect his ultimate purpose in the best and cheapest manner?

"It has happened to me more than once, when taking opportunities of being useful to a young man of merit, that I have experienced opposition in taking him from his books and his drawings and placing a mallet, chisel or trowel in his hand, till rendered confident by the solid knowledge which experience only can bestow, he was qualified to insist on the due performance of workmanship and to judge of merit in the lower as well as the higher departments of a profession in which no kind or degree of practical knowledge is superfluous."

This is doubtless good, sound doctrine, but it does not betoken any very lofty conception of the aims and ends of the profession. But during the first quarter of the nineteenth century Telford stood at the head of the profession of civil engineering, and when, in 1820, the recently formed association of its practitioners for mutual advancement in science, which was termed the Institution of Civil Engineers, desired a prominent leader, he was chosen its president, and held that office until his death in 1834. He does not appear to have contributed to the Institution any papers or discussions on engineering subjects.

Among the members of the Institution at that time was a man thirty years the junior of the president, who, like him, had risen from humble origin, and by his own exertions attained a high rank in the profession, and who, rather oddly, had the same forename, and a surname of two syllables, the initial and final letters of which and the vowel sounds of which were the same as Telford's. This similarity of name has led to some confusion and sometimes to the attributing to one of these men the sayings and doings of the other.

Thomas Tredgold, born in 1788, began life as a carpenter, but soon devoted himself to the study of engineering science and its practice in the office of the Chief Engineer of the Ordnance Bureau. He early recognized the deficiency of the knowledge then existing as to the nature and strength of the materials used in construction, and he studied, experimented and reasoned systematically, and published the results of his labors. His "Treatise on Carpentry," in 1820, was the first published attempt to determine scientifically and practically the data of resistance of beams to transverse flexure. During the next seven years he contributed to the Transactions of the Institution of Civil Engineers papers showing the mode of application of science to engineering problems, and he also published treatises on Warming and Ventilation, on Steam Navigation, on Railroads and Carriages, and on the Steam Engine. It was to him that the Institution turned when it wished to apply for a royal charter, in 1828, and requested him to prepare a definition of civil engineering.

As we look back upon the history of science, theoretical and applied, during the first quarter of the nineteenth century, we can see how a new definition of the profession of civil engineering was needed at that date.

At the very beginning of the century there had occurred a marvelous revolution in the conception of the nature and operation of the laws governing matter and its motion. Lavoisier had revolutionized chemical science and Dalton had propounded a theory of atomic constitution of matter which has been sustained by observation and reason. All matter is composed of a few primal elements in an atomic or minutely subdivided form. These atoms have varying chemical affinity for each other, and, combining in certain proportions, form molecules of matter of various kinds. The study of these combinations has been the business of chemists for the last hundred years, and the laws of combination have been so successfully elucidated that many forms of matter which before were found only in a state of nature can now be artificially produced, and many other forms have been produced which are never found in nature and which are useful for purposes and under conditions where no natural product can be used to advantage. The impetus given to chemical research by the formulation of Dalton's theory was sufficient to establish the fact, early in the century, that chemical affinity was a source of power which could be directed by man intelligently and with prospect of advantage.

Just with the incoming of the century, too, came Rumford's demonstration of the fact that heat was not a material substance, but only a mode of motion. Almost simultaneously was propounded the theory of Thomas Young, that light, too, was not material, but was simply due to vibratory motion in an all-pervading medium to which he gave the name of "the luminiferous ether."

It was in 1800, too, that Volta demonstrated that an electric current could be artificially produced. How it could be controlled and applied to practical use did not yet appear, but a new direction had been given to the minds of those engaged in physical research.

As it became manifest that chemical affinity and heat and light could be controlled and directed and converted into "energy," as Young termed it, the men who had been trained in utilizing the force of gravity turned their attention to the development of these newly understood sources of power. Fitch and Fulton, with the aim of reducing the cost of water transportation, succeeded in applying the steam engine to the propulsion of boats, and Trevithick made successful application of steam propulsion to vehicles on land. Murdock had proved that illuminating gas could be produced and distributed to consumers. The civil engineers of the day had seized on all these inventions and discoveries, and in both Europe and America were designing and constructing works to render them useful to the greatest number of people.

Reviewing then what had been accomplished during the first quarter of the century, Tredgold could not but perceive that civil engineering was something broader and more comprehensive than the mere construction of harbors, breakwaters and canals, and he presented on January 4, 1828, in response to the request of the Institution, this ever-memorable definition of civil engineering:

"Civil Engineering is the art of directing the great sources of power in Nature for the use and convenience of man; being that practical application of the most important principles of natural philosophy which has, in a considerable degree, realized the anticipations of Bacon, and changed the aspect and state of affairs in the whole world."

After a brief sketch of the objects of civil engineering, he added:

"The real extent to which it may be applied is limited only by the progress of science; its scope and utility will be increased with every discovery in philosophy, and its resources with every invention in mechanical or chemical art, since its bounds are unlimited, and equally so must be the researches of its professors." *

A more concise and comprehensive definition of a great truth can hardly be conceived. From a physical and intellectual standpoint, a nobler aim for the exercise of the mental powers cannot be imagined than the direction of the great sources of power in nature for the use and convenience of man. Psychology deals with mind alone, Physics considers the nature and the laws of matter, but Civil Engineering treats of the intelligent direction of the laws governing matter so as to produce effects which will reduce to a minimum the time and physical labor required to supply all the demands of the body of man and leave more opportunity for the exercise of the mental and spiritual faculties. Philosophy, Physics and Civil Engineering must work hand in hand. The philosopher must imagine, the physicist prove by experiment and mathematical computation, and the engineer apply to prac-

* Minutes of Proceedings, Institution of Civil Engineers, Vol. xxvii., 181.

tice, the laws of matter. Each must keep himself informed of the progress made by the others and must aid them by suggestions as to the lines on which research needs to be carried forward. The civil engineer, in attempting to solve some problem of construction, finds that he needs a material which shall possess a certain quality which he cannot discover that any natural product possesses. He calls the chemist to his aid, and he, from a study of the combinations of existing forms of matter which most nearly approach the desired ideal, reasons that some special combination of elements will entirely fulfill the conditions, and he experiments to find whether such combination can be made. Sometimes he is successful in his first attempt and sometimes not. But, whatever the result, he has added to his knowledge of the laws of combinations and has furnished to the philosopher fresh data for his generalizations, and to the engineer a new material for his use.

It not infrequently occurs that, from investigations made for a specific purpose, results are obtained of the greatest usefulness for an entirely different purpose. Thus, in 1855, when Henry Bessemer, inspired solely by that desire "to kill something" which is alike the ruling passion of the rudest savage and the most highly civilized man, bent all his energies to the production of a metallic combination which should be able to resist the force of the highest explosive and so enable a cannon ball to be projected from a gun to a greater distance than ever before, he discovered a method of expelling all foreign substances from iron and then adding a minute quantity of another element, carbon, in such proportions that the original mass was materially changed in character and made more ductile, stronger and stiffer. The product was exactly what the railroad engineer wanted at that time for the bearing surface of his roadway, and the material which had been sought for destructive purposes became a most important factor in facilitating the transportation of men and goods with certainty and safety at high speeds.

As the knowledge of the nature of steel and the precise methods in which it can be manufactured have progressed, the engineer has gradually come to know just what he wants and how it can be produced, and, in his specifications, requires that the particular material of this class which he desires shall be of a certain chemical composition and also possess certain characteristics. The same is the case with almost every material which enters into the construction of engineering works of the present day. Matter in its original state is rarely used. Its chemical condition must be transformed before the engineer can utilize it with any confidence. That almost any desired transformation can be effected was not realized until late in the century. Starting with the atom, the ultimate particle of matter so far comprehended by us, the chemist found that several different kinds of atoms could be identified, and that these would combine in certain ways according to laws which could be formulated. But in the application of these laws and the tabulation of the results, gaps were found to exist which could not be filled without the supposition that other elements existed than those already known. The existence of such elemental substances was confirmed by the revelations of the spectrum analysis, and later on, several of such elements have been actually identified by the use of the electric current in creating vibrations in the ether. The limit is probably not reached yet, but as each new element is discovered its affinities are sought by the chemist, its sensibility to various forms of vibratory motion is investigated by the dynamist, as we may term the physicist who is seeking the laws of either heat or light or electricity, and then it is the function of the civil engineer to study how it can best be applied to the use and convenience of man. For, ever since the beginning of the nineteenth century, the evidence has been cumulative that matter in motion accounts for all physical phenomena, that motion produces energy, that energy is never wasted, but is simply transformed, and that it manifests itself to the senses of man in various modes which are appreciable by the several organs of sense.

What our senses recognize as chemical affinity, heat, light and electricity, are simply conditions of matter induced by vibrations or quivers or waves or strains, whatever we may call them, of different kinds and at different velocities. Neither matter nor motion can be originated by man, but, by a careful study of the sequence of events, control can be acquired of their modes of interaction, and natural phenomena can be artificially reproduced and other phenomena be produced. The intelligent application and direction of such means of control is the function of the civil engineer.

With the advance of science, the scope of civil engineering widened and advanced. The study of the action of forces induced analytical investigation of the means by which forces could be resisted and the best results obtained from proper distribution and arrangement of materials of different kinds. Steamships and locomotive engines were constructed by which the products of the earth and the manufactures of man, by machines and methods not before conceived, could be transported across the seas and overland by artificial highways and across bridges of previously unimagined span; and light and heat and electricity and water could be delivered in the apartment of every person to be used at will.

It was in the carrying out of the delivery of pure and wholesome water and the removal of its unused surplus that the civil engineer first was called on to deal with organic life. That minute organisms affected the comfort and the health of man had been recognized for hundreds of years. In the middle of the seventeenth century Leeuwenhoek, a Dutch maker of microscopes, discovered and described bacteria, and Nicholas Andry, a pathologist, ascribed to them the causation of disease. But later scientists discarded the idea, and it was not until 1831 that any real advances were made in the study of these micro-organisms, and it is only within the last twelve years that it has become thoroughly recognized that the regulation of the growth of living organisms in air and water and sewage is necessary and practicable, and comes within the domain of civil engineering.

Indirectly, however, biological research has been one of the most important factors in the progress of engineering science, by calling the attention of students of physics to the fact that advance and not retrogression is one of the fundamental laws of nature. For the first half of the century, the old ideas of cosmogony, based on an hypothesis unsupported by proof, were prevalent everywhere. It was assumed that the world, in all its details, had been created perfect and had since been simply deteriorating and tending to a final dissolution. "Change and decay, in all around I see," was the dogma of the theologian, the philosopher and the scientist alike. While it had come to be recognized that the forms of inorganic matter could be changed by man, and that by the exercise of man's intelligence, certain characteristics of organic matter and the vital forces with which it was imbued could be modified and perpetuated, it was not considered possible that the superior intelligence which controlled everything could modify or transform such characteristics in any special form of matter.

But in 1859, Charles Darwin, after twenty years of study of the sequence of events in biological phenomena, demonstrated that there was an intelligence beyond that of man, which was constantly acting to change and modify the forms, the habits and the mode of life of animals and plants, and that such action resulted in the perpetuation of the fittest type of organism. The proof was irrefragable, and the effect of his wonderfully clear exposition of the processes by which his conclusions had been reached was marvelous in inducing a co-ordination of thought and a co-operation in methods of procedure in intelligent research in the investigation of all natural phenomena, whether relating to organic or inorganic matter.

In considering the means of directing the great sources of power, the psychological element must not be forgotten. A mere intellectual application of the laws discovered by physical research is not enough to make a civil engineer. Breadth of view, the faculty of analyzing what has been done so as to discover how and why some enterprises have been successful and others have not, and the ability to forecast the future, are essential. These qualities are largely natural, but may be cultivated to a great extent by study and experience. That there has been a wonderful advance in this direction during the nineteenth century is shown by the great number of civil engineers who hold positions of prominence in the management and control of large enterprises which require the exercise of faculties which cannot be acquired in any other way than by experience in the designing, construction and management of engineering works.

A prominent factor in causing this advance in engineering science which has occurred simultaneously on the continent of Europe, in Great Britain and in America, has been the collaboration of scientists. Early in the century it became evident that the multiplication of lines of research demanded a differentiation of the labor of their prosecution and a close co-operation of the workers in any special line, and various associations of specialists were formed to promote various branches of scientific research. By the middle of the century it had become apparent that civil engineering was not the prosecution of a specialty, but was the co-ordination and direction of the work of all specialties in science and its applications. And so in 1852, James Laurie and his associates, following the example of their English brethren, founded the American Society of Civil Engineers, the first and only national organization devoted to "the professional improvement of its members, the encouragement of social intercourse among men of practical science, the advancement of engineering in its several branches and the establishment of a central point of reference and union for its members." To the privileges of its membership may be admitted not only every "professional engineer," but also "any person who, by scientific acquirements or practical experience, has attained a position in his special pursuit qualifying him to co-operate with engineers in the advancement of professional knowledge and practice." This meeting of that society, which now has 2,500 names upon its rolls of membership, and owns a commodious society house with a reference library of some 40,000 titles, is sufficient proof of the wisdom of its founders.

Recognizing, then, that progress is a law of nature, the acceleration of progress is the aim of civil engineering. It strives to stimulate the results of the slow processes of nature, by causing the sources of power to act rapidly in any desired direction. Appreciating, too, the fact that there is constant progress, and that what now seems admirably adapted to our needs may in a short time require to be superseded by improved structures and processes, the tendency of the time is toward the production of works which will have a definite term of life, rather than toward the construction of everlasting monuments. We see that in the old nations, where the effort to build for eternity was made, time has outstripped the intent of the builders and what is antiquated is useless, and we see the same thing in our own streets to-day. The idea of building a monumental structure which will hand one's name down to future ages is a fascinating one, but it is simply a survival of the engineering of the Pharaohs.

The most thorough exemplar of the condition of civil engineering at the beginning of the twentieth century is the modern office building in a great city. One hundred years ago, the man of enterprise who resided fifty miles from a large city and wished to consult an engineer regarding a project for a new canal, arose before daylight, struck a spark from his flint and steel, which, falling on a scrap of tinder, was blown by him into flame and from that a tallow dip was lighted. In the same primitive manner the wood fire was kindled on the kitchen hearth and his breakfast was cooked in a pot and kettle suspended from the iron crane in the fireplace. Entering the cumbrous stage coach, hung on leather springs, which passed his door, he was driven over muddy roads, crossing the narrow streams on wooden trestle bridges and the navigable rivers on a ferryboat, the paddle wheels of which were turned by a mule on a treadmill. At last he was landed in the city, where he walked through dirty streets paved with cobble-stones until he reached his destination, a plain three-story brick building founded on sand, with a damp cellar and a cesspool in the back yard. Entering a dark hall, he climbed a wooden staircase and was ushered into a neat room, rag-carpeted, warmed by a wood fire on the open hearth and lighted by a sperm-oil lamp with one wick, for it was dark by this time. No wonder that before proceeding to business he was glad to take a good stiff noggin of New England rum.

To-day, his grandson, living at the old homestead, while comfortably eating his breakfast which has been cooked over a gas range, reads in his morning paper that the high dam of the irrigation reservoir in Arizona, in which he is interested, sprang a leak the day before, and he telegraphs to his engineer in the city that he will meet him at his office at noon. Then, striking a match, he lights the lamp of his automobile, which is fed by petroleum brought 200 miles underground in pipes from the wells, rolls over macadamized roads to the railroad station, where he boards a luxuriously appointed train by which he is carried above all highways, through tunnels, under rivers, or across them on long-span steel bridges, and in an hour is deposited in the heart of the city, where he has his choice of proceeding to his destination through clean and asphalt-paved streets in electric surface cars at 9 miles an hour, elevated steam cars at 12 miles an hour, or through well-lighted and ventilated tunnels at 15 miles an hour. Reaching the spot his grandfather had visited, he finds there a huge and highly decorated building, twenty or more stories high. Founded on the primeval rock, far below the surface of the natural ground, the superjacent strata of compressible material having been penetrated by caissons of sheet metal sunk by the use of air compressed by powerful pumps driven by steam or electricity generated at a power station half a mile or more away, and these caissons filled with a manufactured rock such as the ordinary processes of nature would require millions of years to produce, there is erected a cage of steel, the composition of which has been specified, and the form and mode of construction of which have been so computed that the force of the elements cannot overthrow the structure or even cause it to sway perceptibly. Towering above the courts of law, the temples of religion and the palaces of the arts, the meshes of this mighty cage are filled with products of the earth, the mine and the forest, transformed so as to be strong and light and incombustible, and all interwoven with pipes and wires, each in its proper place and noted on the plans. In one set of these pipes there is pure water, which has been collected from a mountain area of igneous geological formation, depopulated and free from swamps, on which a record of the daily rainfall is kept, and in which impounding reservoirs have been constructed by masonry dams across its valleys. From these reservoirs the water, after filtration through clean sand, is conveyed 30 or 40 miles through steel or masonry conduits to covered reservoirs, whence it is drawn, as needed, through cast-iron pipes to the building where it is to be used, and there distributed to all parts of it, chilled nearly to the freezing point through one system of pipes or heated nearly to the boiling point through another system. Another set of pipes carries steam, which, passing through radiators, keeps the temperature of the air throughout the building at the proper standard for comfort. Sanitary conveniences are provided everywhere, and all wastes are consumed within the building by the surplus heat generated, leaving only ashes to be removed. Wires convey electric currents to all points, so that the occupant of a room, sitting at his desk, can by the touch of a button ventilate his apartment, illuminate it, call a messenger, be kept informed of every fluctuation in the markets, converse with anybody who is not "busy" within 40 miles of where he sits, and if entirely "up to date" can require his autograph and portrait to be reproduced before his eyes for identification. He dictates his correspondence and his memoranda, and "takes his pen in hand" only to sign his name. He need not leave his seat except to consult the photograph hanging on his wall, which shows to him the latest condition of the mine, the railroad, the arid lands irrigated, the swamps reclaimed, the bridge in progress, the steamship, the water-works, the tunnel or the railroad, the dam, the filter or the sewage works, the town, the machine, the power plant or the manufacturing establishment in which he is most interested.

Entering the brilliantly lighted hallway of this building, the air of which is kept in circulation by the plunging up and down of half a dozen elevators, the visitor is lifted at a speed of 500 feet a minute, past floor after floor, crowded with the offices of financiers, managers, and promoters of traffic and of trade, lawyers, chemists, contractors, manufacturers, to the headquarters of the controlling genius of the whole organism, the civil engineer. For he it is to whom all the members of this microcosm must apply for aid and advice in the successful operation of their respective occupations. It is not his to mechanically transform elements into matter, or matter into other forms, or to show how energy may be produced, but to direct the application of energy to the various forms of matter, original or produced, in such way as to bring about the most satisfactory results in the most speedy and economical manner.

He has grown with the growth of the nineteenth century, and is, so far as the relations between man and matter are concerned, its most striking product. And so, while the definition given in the "American Edition of the Encyclopedia," which appeared at the beginning of the century, that "civil engineers are a denomination which comprises an order or profession of persons highly respectable for their talents and scientific attainments and eminently useful under this appellation," is still true, it is hardly probable that the compiler of the Twentieth Century Encyclopedia will be content to let it stand without further explanation.

But the end is not yet; there are still many problems of nature unsolved. The experience of every day shows that there are sources of power not yet fully developed, and we cannot but say with the great poet:

"I doubt not through the ages one increasing purpose runs,
And the thoughts of men are widened with the process of the suns."

J. JAMES R. CROES.

THAIS AND SERAPIO.

Some excitement was caused in Paris a few weeks ago by the report that the remains of the beautiful Thais, the celebrated Greek courtésan, had been found, and that they might be seen at the Guimet Museum.

STATUETTE REPRESENTING A SERVANT.

It turned out, however, that the remains were those of another Thais, a saint and a martyr, who had nothing in common with the friend of Alexander the Great. Yet the discovery is none the less of genuine importance. The finder of the Thais under consideration is M. Gayet, the distinguished archæologist, who was commissioned by the Minister of Public Instruction of France to make excavations in Egypt. The valuable relic was discovered during the course of researches made in the Cemetery of Antinoe, which is now buried beneath the sand.

In order to obtain precise information, says Le Monde Illustré, we first saw M. Guimet.

"The Thais exhibited," said the eminent superintendent of the museum, "must have been a Christian martyr, who died in the third century of our era. Everything seems to prove this.

"I do not speak of the body only, which has been decapitated, and of the burned skin of the legs and arms, which a physician might examine from the technical viewpoint of the tortures inflicted, but may state that in her tomb there were found four braided palms intact, a symbolical mark of the first ages—palms of the martyrs.

"You are not ignorant of the fact that, according to Egyptian belief, every being had a double body that permitted him or her after death to live again with a second body the same life that was passed with his or her first one upon earth. It was therefore customary to put into the tomb the objects that were familiar to the defunct in order that he or she might continue to make use of them.

"In the sarcophagus of Thais there was found a sort of chaplet in the form of a stairway with three steps provided with apertures in which were placed pins that took the place of rosary beads, a metal cross, and a piece that permitted of the manufacture of consecrated wafers, and that somewhat resembled an iron for making waffles. There was likewise found a bouquet of roses of Jericho and a bouquet of immortelles; and especially, what was a distinctive sign, the martyr held in her arms a braided rush basket and a vessel. These tokens seem to recall the words of Saint Jerome: 'None is so rich as he who bears the body of Christ in a basket of braided rushes and his blood in a glass vessel.' Moreover, the martyr was buried with her gala attire, richly embroidered and woven, with a collar of uncut precious stones around her neck. Above the coffin, in the sand, was found a jar that must, according to its inscription, have contained wine of Miké.

"Alongside of Thais was found a unique piece—the body of an anchorite. This unfortunate, whose name was Serapio, was interred just as he had lived. An iron ring encircled his neck and supported a huge iron cross, which, through its weight of seventy-seven pounds, had caused the head to assume an inclining position that it preserved after death. The head was enveloped with and concealed in seven superposed woolen hoods. The whole body was girdled with huge belts of iron that compressed the stomach and abdomen, while heavy iron rings encircled the legs, which they embraced so tightly that after all the flesh had disappeared they could not be removed without breaking the bones.

"Alongside of the body there was a stick cut in two—a sign indicating that the unfortunate, after having left half of his daily support upon earth, would be very happy to begin his miserable existence again in leaning upon the second half. This stick had been given to him by another anchorite, Macarius, a disciple of the famous St. Anthony."

Upon leaving M. Guimet, says Le Monde Illustré, we met M. Gayet, who was putting the last touches upon his exhibit, and who said to us while arranging his show cases:

"My excavations were begun in 1898. I commenced with almost nothing, say five hundred francs, and yet the very first year I discovered at Antinoe a temple—that of Ramises. Then I was encouraged by the Chamber of Commerce of the city of Lyons and also by that good-hearted man, Guimet. With a grant of three thousand francs I found some interesting things, and, among others some ancient silk fabrics that greatly captivated the silk trade.

"Last year I brought to light more than ten thousand tombs, which were, on an average, covered with 70 cubic feet of sand, for, up to the present, my excavations have been made only in sand. As you may see, that puts each tomb at about fifty centimes—almost nothing. Unfortunately, I have discovered the tombs only of people of the middle class. The tombs of the

A PAGE OF GREEK GRAMMAR.

patricians must have been located upon the hillsides and excavated in stone. From what I have discovered there is no doubt that unheard-of wealth exists in these sarcophagi. But work on these would be much more troublesome and would require adequate funds, say about five thousand francs.

"I have as yet excavated only in two and a half out of the seven miles included in the Necropolis of Antinoe. And yet, see, I need space for the exhibition of all that I have brought home. My exhibit may be divided into three parts: Ancient Egypt, Roman Egypt and Byzantine Egypt.

"In the first part, we have a cedar sarcophagus that contained the chancellor Pakhet-M-Hat, who lived 2,500 years before Christ. I found in it a number of things—some pottery, a bronze mirror and some

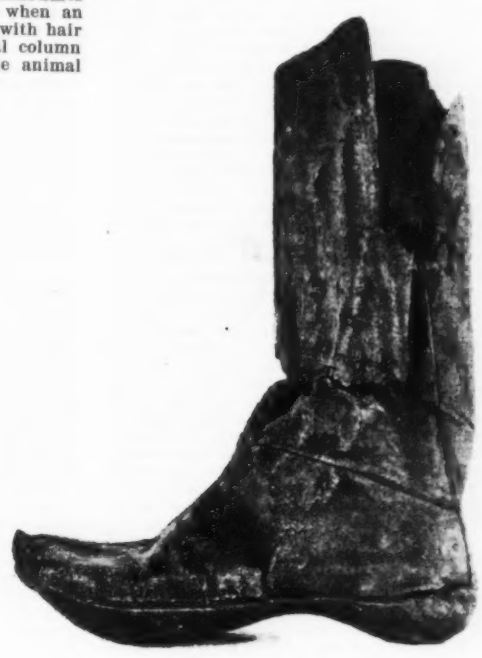
THAIS AND SERAPIO.

statuettes. These latter are very curious and represent servants of the chancellor, whose duty it was to bring him food during his death. One of them is represented with a basket on the head filled with provisions and holding in the hand a plucked fowl. The feet of the servant have fallen into dust.

"Finally, twenty-one glass cases are reserved for the Byzantine epoch and contain (in addition to Thais and Serapio) sixteen bodies with the clothing, embroideries and tools of the epoch.

"Among these latter objects, there is an embroidery characteristic of the second century, representing in the center a female head with eyes curiously painted, and with goddesses and fishes all around. Was not this design truly wonderful for the epoch?

EMBROIDERY OF THE FOURTH CENTURY.



BOOT OF THE FOURTH CENTURY.

"Then, again, here are specimens of shoemaking of the same epoch, a Persian boot and embroidered leather slippers, and then all the tools that were used by the spinner Euphemia, from the series of spindles and package of knitting needles to the reel, distaff and hecule. It might be said that all these objects were contemporaneous.

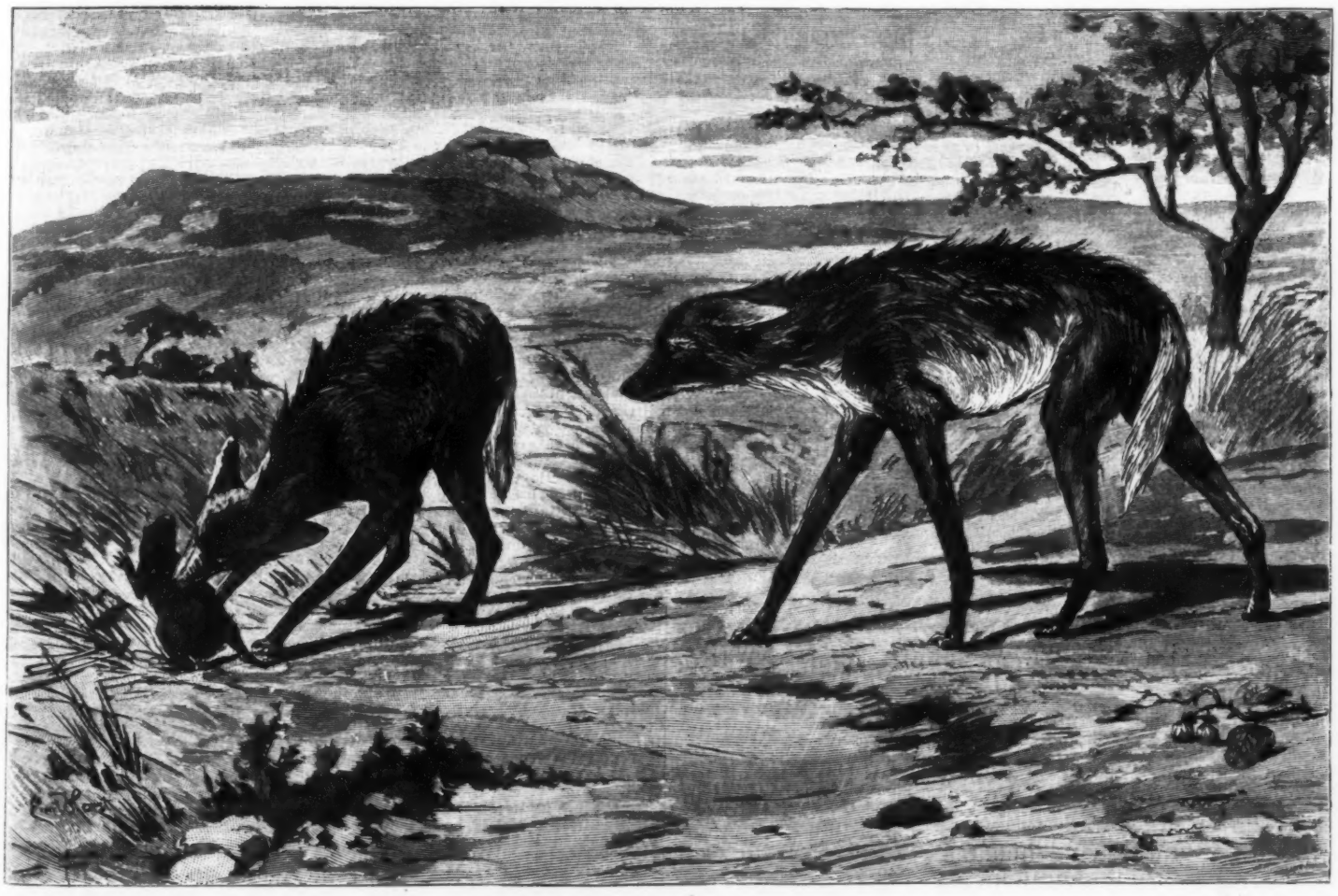
"Further along we have the body of a female teacher, which was found with books on geography, grammar and mathematics. These books were composed of several boards covered with soft wax in which the characters were traced by means of a style provided with a metallic point."

And M. Gayet continued to show us wonders upon wonders; but they were too many, and so we are obliged to stop in the description of the treasures of this curious as well as historic exhibit.

THE MANED WOLF.

THE maned wolf (*Canis jubatus*, Desm.) is a rare animal, so rare, indeed, that it is seldom found in zoological museums and still more seldom in menageries. Whoever has once seen the creature will not readily forget its peculiar form and its strange appearance. On its long legs—much longer than those of any other canine species—the maned wolf slowly and cautiously stalks about. The great, broad ears are sometimes attentively pricked forward, sometimes folded back close to the neck, particularly when an attack is feared. The gaunt body is covered with hair which increases in length toward the spinal column and forms a mane which bristles when the animal is excited. The tail is bushy like that of a fox, but does not extend to the feet. The head, with its pointed snout, is almost delicately formed. The eyes are small, and the pupils round as in the ordinary wolf. In color the fur of the maned wolf is a magnificent fox-red, which fades to a lighter shade on the under side of the body. The tail, near the end, is white; the mane and feet are black.

The maned wolf is the largest wild dog in South America, writes Dr. Bolan in the Illustrirte Zeitung. Its habitat is southern Brazil, Paraguay, and Argentine Republic. It prefers the open rather than the woody country, but during the day it hides in the bush or in the tall grass of the pampas, appearing in the daytime only in uninhabited places. The wolf's fine hearing and long legs are of no small service in detecting and avoiding a dangerous enemy. Large though the creature may be, its prey is the guinea-pig or any other small animal; cattle and sheep it never attacks. According to Azara, shrimps, crabs, and like marine animals are also eaten. Burmeister states that the maned wolf also derives part of its nourishment from the fruit of the tree *Solanum lycocarpum*, Saint-Hilaire, of the night shade family. For that reason the fruit is called Fruito del lobo (wolf's fruit) in the Brazilian province of Minas Geraes. In captivity, the maned wolf is fed on beef, horse, and goat's meat. The animal will eat dates, but will not touch oranges or apples, or even tomatoes, which so closely resemble "wolf's fruit." In some parts of Brazil the meat of the maned wolf is eaten. Burmeister, to whom it was served as venison, found it palatable though somewhat tough. But perhaps this "venison" came from an old wolf.



THE MANED WOLF OF SOUTH AMERICA.

ASTRONOMY AT THE VATICAN.

IT is reported that an American citizen and a member of the Roman Catholic Church, who is much interested in celestial and terrestrial physics, has made what he calls an humble offering to the Pope in the shape of a telescope which is said to exceed greatly in size even the one shown at the Paris Exhibition of last year. His Holiness is stated to have accepted

the gift, which is now destined to find a prominent place among the many valuable instruments of research of the Vatican Observatory, which was presented just over a century ago by Cardinal Zelada with the then famous Dollond telescope. In connection with this statement it may be of interest to note that a very erroneous notion generally prevails with regard to the original development of the Vatican Observatory, and that usually a quite recent date is assigned to it, though it would appear to be the oldest of its kind, with the exception, probably, of one at Peking. It is true that the Vatican Observatory in its present outward appearance and constitution only dates back to 1888, the year in which Pope Leo XIII. celebrated the fiftieth anniversary of his priesthood. But there seems to be scarcely any doubt that an observatory tower was erected in Rome as far back as some time previous to 1582, and, as it would appear, chiefly in connection with the reform of the calendar. According to B. Crescenzi, the author of the important work which is entitled "Nautica Mediterranea," and which was published in Rome in 1607, Pope Gregory XIII. was mainly responsible for its erection. It is recorded that the tower was intended exclusively for astronomical observations and researches, and there is, from an historical point of view, every reason to suppose that it was the first celestial watch-tower ever built in Rome. Since its erection, however, and partial endowment by Pope Gregory XIII., it passed through so many and so highly complicated vicissitudes that it now forms for the astronomical student a large and interesting field of historical speculation. We are, therefore, not surprised to observe that while it was at one time most anxiously cared for, and the scientific work done there may be termed to have been of the utmost importance, at another time it was utterly neglected and devoid of any scientific management or control; finally, it became of world-wide renown at the beginning of the last century, chiefly on account of the scientific labors and able management of Philip Gili, who for a period extending over thirty years was its director. After the death, however, of Gili, which occurred in 1821, it again became quite disorganized. All the instruments and records were dispersed and the observatory itself was entirely deserted, both as regards the scientific and social interests attached to it. In 1888 the Vatican Observatory commenced a new epoch in its history. In that year, as already mentioned, the commemoration of the fiftieth anniversary of the priesthood of Pope Leo XIII. took place, and on that occasion all the instruments and apparatus given by members of the Roman Catholic Church interested in celestial and terrestrial physics were brought together, and it then occurred to the organizers of the science section of the Vatican Exposition that they would find a suitable home in the old Gregorian Tower. The suggestion was warmly approved and soon carried into effect, and Father Denza, a great friend of Secchi, was now called upon to undertake the management of the revived observatory. He began his work in 1889 with a very interesting and varied programme, which he and his able assistants have well carried out. The investigations which were thus introduced there relate to meteorology, terrestrial magnetism, astronomy, and lastly geodynamics. In addition, the building is well situated for meteorological researches and observations; moreover, it is well equipped with the most modern instruments necessary for the continuous record of meteorological data. Since 1889 it has always kept well apace with the times and would now bear comparison with any observatory in Europe.—The London Lancet.

THE SUPPRESSION OF TUBERCULOSIS.*

THE task with which this congress will have to busy itself is one of the most difficult, but it is also one in which labor is most sure of its reward.

I need not point again to the innumerable victims tuberculosis annually claims in all countries, or to the boundless misery it brings on the families it attacks. You all know that there is no disease which inflicts such deep wounds on mankind as this. All the greater, however, would be the general joy and satisfaction if the efforts that are being made to rid mankind of this enemy, which consumes its inmost marrow, were crowned with success.

There are many, indeed, who doubt the possibility of successfully combating this disease, which has existed for thousands of years, and has spread all over the world. This is by no means my opinion. This is a conflict into which we may enter with a surely founded prospect of success, and I will tell you the reasons on which I base this conviction.

Only a few decades ago the real nature of tuberculosis was unknown to us; it was regarded as a consequence, as the expression, so to speak, of social misery, and, as this supposed cause could not be got rid of by simple means, people relied on the probable gradual improvement of social conditions, and did nothing. All this is altered now. We know that social misery does indeed go far to foster tuberculosis, but the real cause of the disease is a parasite—that is, a visible and palpable enemy which we can pursue and annihilate, just as we can pursue and annihilate other parasitic enemies of mankind.

Strictly speaking, the fact that tuberculosis is a preventable disease ought to have become clear as soon as the tubercle-bacillus was discovered, and the properties of this parasite and the manner of its transmission became known. I may add that I, for my part, was aware of the full significance of this discovery from the first, and so will everybody have been who had convinced himself of the causal relation between tuberculosis and the tubercle-bacillus. But the strength of a small number of medical men was inadequate to the conflict with a disease so deeply rooted in our habits and customs. Such a conflict requires the co-operation of many, if possible of all, medical men, shoulder to shoulder with the state and the whole population; but now the moment when such co-operation is possible seems to have come. I suppose there is hardly any medical man now who denies the parasitic nature of tuberculosis, and among the non-medical public, too, the knowledge of the nature of the disease has been widely propagated.

Another favorable circumstance is that success has recently been achieved in the combating of several parasitic diseases, and that we have learned from these examples how the conflict with pestilences is to be carried on.

The most important lesson we have learned from the said experience is that it is a great blunder to treat pestilences uniformly. This was done in former times; no matter whether the pestilence in question was cholera, plague, or leprosy, isolation, quarantine, useless disinfection were always resorted to. But now we know that every disease must be treated according to its own special individuality, and that the measures to be taken against it must be most accurately adapted to its special nature, to its etiology. We are entitled to hope for success in combating tuberculosis only if we keep this lesson constantly in view. As so extremely much depends just on this point, I shall take the liberty to illustrate it by several examples.

The pestilence which is at this moment in the foreground of interest, the bubonic plague, may be instructive to us in several respects.

People used to act upon the conviction that a plague patient was in the highest degree a center of infection, and that the disease was transmitted only by plague patients and their belongings. Even the most recent international agreements are based on this conviction. Although, as compared with formerly, we now have the great advantage that we can, with the aid of the microscope and of experiments on animals, recognize every case of plague with absolute certainty, and although the prescribed inspection of ships, quarantine, the isolation of patients, the disinfection of infected dwellings and ships are carried out with the utmost care, the plague has, nevertheless, been transmitted everywhere, and has in not a few places assumed grave dimensions. Why this has happened we know very well, owing to the experience quite recently gained as to the manner in which the plague is transmitted. It has been discovered that only those plague patients that suffer from plague-pneumonia—a condition which is fortunately infrequent—are centers of infection, and that the real transmitters of the plague are the rats. There is no longer any doubt that, in by far the majority of the cases in which the plague has been transmitted by ocean traffic, the transmission took place by means of plague among the ship rats. It has also been found that, wherever the rats were intentionally or unintentionally exterminated, the plague rapidly disappeared; whereas at other places, where too little attention had been paid to the rat plague, the pestilence continued. This connection between the human plague and the rat plague was totally unknown before, so that no blame attaches to those who devised the measures now in force against the plague if the said measures have proved unavailing. It is high time, however, that this enlarged knowledge of the etiology of the plague be utilized in international as well as in other traffic. As the human plague is so dependent on the rat plague, it is intelligible that protective inoculation and the application of antitoxic serum have had so little effect. A certain number of human beings may have been saved from the disease by that, but the general spread of the pestilence has not been hindered in the least.

With cholera the case is essentially different; it may, under certain circumstances, be transmitted directly from human beings to other human beings, but its main and most dangerous propagator is water, and therefore, in the combating of cholera, water is the first thing to be considered. In Germany, where this principle has been acted on, we have succeeded for four years in regularly exterminating the pestilence (which was introduced again and again from the infected neighboring countries) without any obstruction of traffic.

Hydrophobia, too, is not void of instruction for us. Against this disease the so-called protective inoculation proper has proved eminently effective as a means of preventing the outbreak of the disease in persons already infected, but, of course, such a measure can do nothing to prevent infection itself. The only real way of combating this pestilence is by compulsory muzzling. In this matter also we have had the most satisfactory experience in Germany, but have at the same time seen that the total extermination of the pestilence can be achieved only by international measures, because hydrophobia, which can be very easily and rapidly suppressed, is always introduced again year after year from the neighboring countries.

Permit me to mention only one other disease, because it is etiologically very closely akin to tuberculosis, and we can learn not a little for the furtherance of our aims from its successful combating. I mean leprosy. It is caused by a parasite which greatly resembles the tubercle-bacillus. Just like tuberculosis, it does not break out till long after infection, and its course is almost slower. It is transmitted only from person to person, but only when they come into close contact, as in small dwellings and bedrooms. In this disease, accordingly, immediate transmission plays the main part. Transmission by animals, water, or the like is out of the question. The combative measures, accordingly, must be directed against this close intercourse between the sick and the healthy. The only way to prevent this intercourse is to isolate the patients. This was most rigorously done in the Middle Ages by means of numerous leper-houses, and the consequence was that leprosy, which had spread to an alarming extent, was completely stamped out in central Europe. The same method has been adopted quite recently in Norway, where the segregation of lepers has been ordered by a special law. But it is extremely interesting to see how this law is carried out. It has been found that it is not at all necessary to execute it strictly, for the segregation of only the worst cases, and even of only a part of these, sufficed to produce a diminution of leprosy. Only so many infectious cases had to be sent to the leper-houses that the number of fresh cases kept regularly diminishing from year to year. Consequently the stamping out of the disease has lasted much longer than it would have lasted if every leper had been inexorably consigned to a leper-house, as in the Middle Ages; but in this way, too, the same purpose is gained, slowly, indeed, but without any harshness.

These examples may suffice to show what I am driving at, which is to point out that, in combating pestilences, we must strike at the root of the evil, and must not squander force in subordinate ineffective measures. Now the question is whether what has hitherto been done, and what is about to be done, against tuberculosis really strikes at the root of tuberculosis, so that it must sooner or later die.

In order to answer this question it is necessary first and foremost to inquire how infection takes place in tuberculosis. Of course, I presuppose that we understand by tuberculosis only those morbid conditions which are caused by the tubercle-bacillus.

In by far the majority of cases of tuberculosis the disease has its seat in the lungs, and has also begun there. From this fact it is justly concluded that the germs of the disease, i. e., the tubercle-bacilli, must have got into the lungs by inhalation. As to the question where the inhaled tubercle-bacilli have come from, there is also no doubt. On the contrary, we know with certainty that they get into the air with the sputum of consumptive patients. This sputum, especially in advanced stages of the disease, almost always contains tubercle-bacilli, sometimes in incredible quantities. By coughing, and even speaking, it is flung into the air in little drops, i. e., in a moist condition, and can at once infect persons who happen to be near the coughers. But then it may also be pulverized when dried, in the linen or on the floor for instance, and get into the air in the form of dust.

In this manner a complete circle, a so-called *circulus vitiosus*, has been formed for the process of infection, from the diseased lung, which produces phlegm and pus containing tubercle-bacilli, to the formation of moist and dry particles (which, in virtue of their smallness, can keep floating a good while in the air), and finally to new infection, if particles penetrate with the air into a healthy lung and originate the disease anew. But the tubercle-bacilli may get to other organs of the body in the same way, and thus originate other forms of tuberculosis. This, however, is a considerably rarer case. The sputum of consumptive people, then, is to be regarded as the main source of the infection of tuberculosis. On this point, I suppose, all are agreed. The question now arises whether there are not other sources too, copious enough to demand consideration in the combating of tuberculosis.

Great importance used to be attached to the hereditary transmission of tuberculosis. Now, however it has been demonstrated by thorough investigation that, though hereditary tuberculosis is not absolutely nonexistent, it is nevertheless extremely rare, and we are at liberty, in considering our practical measures to leave this form of origination entirely out of account.

But another possibility of tubercular infection exists, as is generally assumed, in the transmission of the germs of the disease from tubercular animals to man. This manner of infection is generally regarded nowadays as proved, and as so frequent that it is even looked upon by not a few as the most important, and the most rigorous measures are demanded against it. In this congress also the discussion of the danger with which the tuberculosis of animals threatens man will play an important part. Now, as my investigations have led me to form an opinion deviating from that which is generally accepted, I beg your permission, in consideration of the great importance of this question, to discuss it a little more thoroughly.

Genuine tuberculosis has hitherto been observed in almost all domestic animals, and most frequently in poultry and cattle. The tuberculosis of poultry, however, differs so much from human tuberculosis that we may leave it out of account as a possible source of infection for man. So, strictly speaking, the only kind of animal tuberculosis remaining to be considered is the tuberculosis of cattle, which, if really transferable to man, would, indeed, have frequent opportunities of infecting human beings through the drinking of the milk and the eating of the flesh of diseased animals.

Even in my first circumstantial publication on the etiology of tuberculosis I expressed myself regarding the identity of human tuberculosis and bovine tuberculosis with reserve. Proved facts which would have enabled me sharply to distinguish these two forms of the disease were not then at my disposal, but sure proofs of their absolute identity were equally undiscoverable, and I therefore had to leave this question undecided. In order to decide it, I have repeatedly resumed the investigations relating to it, but so long as I experimented on small animals, such as rabbits and guinea-pigs, I failed to arrive at any satisfactory result, though indications which rendered the difference of the two forms of tuberculosis probable were not wanting. Not till the complaisance of the Ministry of Agriculture enabled me to experiment on cattle, the only animals really suitable for these investigations, did I arrive at absolutely conclusive results. Of the experiments which I have carried out during the last two years along with Prof. Schültz, of the Veterinary College in Berlin, I will tell you briefly some of the most important.

A number of young cattle which had stood the tuberculin test, and might, therefore, be regarded as free from tuberculosis, were infected in various ways with pure cultures of tubercle-bacilli taken from cases of human tuberculosis; some of them got the tubercular sputum of consumptive patients direct. In some cases the tubercle-bacilli or the sputum were injected under the skin; in others into the peritoneal cavity, in others into the jugular vein. Six animals were fed with tubercular sputum almost daily for seven or eight months; four repeatedly inhaled great quantities of bacilli, which were distributed in water and scattered with it in the form of spray. None of these cattle (there were nineteen of them) showed any symptoms of disease, and they gained considerably in weight. From six to eight months after the beginning of the experiments they were killed. In their internal organs not a trace of tuberculosis was found. Only at the places where the injections had been made small suppurative foci had formed, in which few tubercle-bacilli could be found. This is exactly what one finds when one injects dead tubercle-bacilli under the skin of animals liable to contagion. So the animals we experimented

* Paper on "The Combating of Tuberculosis in the Light of the Experience that has been gained in the Successful Combating of other Infectious Diseases," by Prof. Robert Koch, read at the British Congress on Tuberculosis, July 23.

on were affected by the living bacilli of human tuberculosis exactly as they would have been by dead ones; they were absolutely insusceptible to them.

The result was utterly different, however, when the same experiment was made on cattle free from tuberculosis with tubercle-bacilli that came from the lungs of an animal suffering from bovine tuberculosis. After an incubation period of about a week the severest tubercular disorders of the internal organs broke out in all the affected animals. It was all one whether the infecting matter had been injected only under the skin or into the peritoneal cavity or the vascular system. High fever set in, and the animals became weak and lean; some of them died after a month and a half to two months, others were killed in a miserably sick condition after three months. After death, extensive tubercular infiltrations were found at the place where the injections had been made, and in the neighboring lymphatic glands, and also far advanced alterations of the internal organs, especially the lungs and the spleen. In the cases in which the injections had been made into the peritoneal cavity the tubercular growths which are so characteristic of bovine tuberculosis were found on the omentum and peritoneum. In short, the cattle proved just as susceptible to infection by the bacillus of bovine tuberculosis as they had proved insusceptible to infection by the bacillus of human tuberculosis. I wish only to add that preparations of the organs of the cattle which were artificially infected with bovine tuberculosis in these experiments are exhibited in the Museum of Pathology and Bacteriology.

An almost equally striking distinction between human and bovine tuberculosis was brought to light by a feeding experiment with swine. Six young swine were fed daily for three months with the tubercular sputum of consumptive patients. Six other swine received bacilli of bovine tuberculosis with their food daily for the same period. The animals that were fed with sputum remained healthy and grew lustily, whereas those that were fed with the bacilli of bovine tuberculosis soon became sickly, were stunted in their growth, and half of them died. After three months and a half the surviving swine were all killed and examined. Among the animals that had been fed with sputum no trace of tuberculosis was found, except here and there little nodules in the lymphatic glands of the neck, and in one case a few gray nodules in the lungs. The animals, on the other hand, which had eaten bacilli of bovine tuberculosis had, without exception (just as in the cattle experiment), severe tubercular diseases, especially tubercular infiltration of the greatly enlarged lymphatic glands of the neck and of the mesenteric glands, and also extensive tuberculosis of the lungs and the spleen.

The difference between human and bovine tuberculosis appeared not less strikingly in a similar experiment with asses, sheep and goats into whose vascular system the two kinds of tubercle-bacilli were injected.

Our experiments, I must add, are not the only ones that have led to this result. If one studies the older literature of the subject, and collates the reports of the numerous experiments that were made in former times by Chauveau, Günther and Harms, Bollinger and others, who fed calves, swine, and goats with tubercular material, one finds that the animals that were fed with the milk and pieces of the lungs of tubercular cattle always fell ill of tuberculosis, whereas those that received human material with their food did not. Comparative investigations regarding human and bovine tuberculosis have been made very recently in North America by Smith, Dinwiddie, and Frothingham, and their result agreed with that of ours. The inambiguous and absolutely conclusive result of our experiments is due to the fact that we chose methods of infection which exclude all sources of error, and carefully avoided everything connected with the stalling, feeding and tending of the animals that might have a disturbing effect on the experiments.

Considering all these facts, I feel justified in maintaining that human tuberculosis differs from bovine, and cannot be transmitted to cattle. It seems to me very desirable, however, that these experiments should be repeated elsewhere, in order that all doubt as to the correctness of my assertion may be removed.

I wish only to add that, owing to the great importance of this matter, the German Government has appointed a commission to make further inquiries on the subject.

But, now, how is it with the susceptibility of man to bovine tuberculosis? This question is far more important to us than that of the susceptibility of cattle to human tuberculosis, highly important as that is, too. It is impossible to give this question a direct answer, because, of course, the experimental investigation of it with human beings is out of the question. Indirectly, however, we can try to approach it. It is well known that the milk and butter consumed in great cities very often contain large quantities of the bacilli of bovine tuberculosis in a living condition, as the numerous infection experiments with such dairy products on animals have proved. Most of the inhabitants of such cities daily consume such living and perfectly virulent bacilli of bovine tuberculosis, and unintentionally carry out the experiment which we are not at liberty to make. If the bacilli of bovine tuberculosis were able to infect human beings, many cases of tuberculosis caused by the consumption of alimenta containing tubercle-bacilli could not but occur among the inhabitants of great cities, especially the children. And most medical men believe that this is actually the case.

In reality, however, it is not so. That a case of tuberculosis has been caused by alimenta can be assumed with certainty only when the intestine suffers first—*i. e.*, when a so-called primary tuberculosis of the intestine is found. But such cases are extremely rare. Among many cases of tuberculosis examined after death, I myself remember having seen primary tuberculosis of the intestine only twice. Among the great *post-mortem* material of the Charité Hospital in Berlin ten cases of primary tuberculosis of the intestine occurred in five years. Among 933 cases of tuberculosis in children at the Emperor and Empress Frederick's Hospital for Children, Baginsky never found tuberculosis of the intestine without simultaneous disease of the lungs and the bronchial glands. Among 3,104 *post mortems* of tubercular children, Biedert observed only sixteen cases of primary tuberculosis of the intestine. I could cite from the literature of the subject many more statistics of the same kind, all indubitably showing that primary tuberculosis of the intestine, especially among children, is a comparatively rare disease, and of these few cases that have been enumerated, it is by no means certain that they were due to infection by bovine tuberculosis. It is just as likely that they were caused by the widely propagated bacilli of human tuberculosis, which may have got into the digestive canal in some way or other—for instance, by swallowing saliva of the mouth. Hitherto nobody could decide with certainty in such a case whether the tuberculosis of the intestine was of human or of animal origin. Now we can diagnose them. All that is necessary is to cultivate in pure culture the tubercle-bacilli found in the tubercular material, and to ascertain whether they belong to bovine tuberculosis by inoculating cattle with them. For this purpose I recommend subcutaneous injection, which yields quite specially characteristic and convincing results. For half a year past I have occupied myself with such investigations; but, owing to the rareness of the disease in question, the number of the cases I have been able to investigate is but small. What has hitherto resulted from this investigation does not speak for the assumption that bovine tuberculosis occurs in man.

Though the important question whether man is susceptible to bovine tuberculosis at all is not yet absolutely decided, and will not admit of absolute decision to-day or to-morrow, one is nevertheless already at liberty to say that, if such a susceptibility really exists, the infection of human beings is but a very rare occurrence. I should estimate the extent of infection by the milk and flesh of tubercular cattle, and the butter made of their milk, as hardly greater than that of hereditary transmission, and I therefore do not deem it advisable to take any measures against it.

So the only main source of the infection of tuberculosis is the sputum of consumptive patients, and the measures for the combating of tuberculosis must aim at the prevention of the dangers arising from its diffusion. Well, what is to be done in this direction? Several ways are open. One's first thought might be to consign all persons suffering from tuberculosis of the lungs, whose sputum contains tubercle-bacilli, to suitable establishments. This, however, is not only absolutely impracticable, but also unnecessary. A consumptive who coughs out tubercle-bacilli is not necessarily a source of infection on that account, so long as he takes care that his sputum is properly removed and rendered innocuous. This is certainly true of very many patients, especially in the first stages, and also of those who belong to the well-to-do classes, and are able to procure the necessary nursing. But how is it with people of very small means? Every medical man who has often entered the dwellings of the poor, and I can speak on this point from my own experience, knows how sad is the lot of consumptives and their families there. The whole family have to live in one or two small, ill-ventilated rooms. The patient is left without the nursing he needs, because the able-bodied members of the family must go to their work. How can the necessary cleanliness be secured under such circumstances? How is such a helpless patient to remove his sputum so that it may do no harm? But let us go a step further and picture the condition of a poor consumptive patient's dwelling at night. The whole family sleep crowded together in one small room. However cautious he may be, the sufferer scatters the morbid matter secreted by his diseased lungs every time he coughs, and his relatives close beside him must inhale this poison. Thus whole families are infected. They die out, and awaken in the minds of those who do not know the infectiousness of tuberculosis the opinion that it is hereditary, whereas its transmission in the cases in question was due solely to the simplest process of infection, which do not strike people so much, because the consequences do not appear at once, but generally only after the lapse of years.

Often, in such circumstances, the infection is not restricted to a single family, but spreads in densely inhabited tenement-houses to the neighbors, and then, as the admirable investigations of Biggs have shown in the case of the densely peopled parts of New York, regular nests or foci of disease are formed. But, if one investigates these matters more thoroughly, one finds that it is not poverty *per se* that favors tuberculosis, but the bad domestic conditions under which the poor everywhere, but especially in great cities, have to live. For, as the German statistics show, tuberculosis is less frequent, even among the poor, when the population is not densely packed together, and may attain very great dimensions among a well-to-do population when the domestic conditions, especially as regards the bedrooms, are bad, as in the case, for instance, among the inhabitants of the North Sea coast. So it is the overcrowded dwellings of the poor that we have to regard as the real breeding places of tuberculosis; it is out of them that the disease always crops up anew, and it is to the abolition of these conditions that we must first and foremost direct our attention if we wish to attack the evil at its root, and to wage war against it with effective weapons.

This being so, it is very gratifying to see how efforts are being made in almost all countries to improve the domestic conditions of the poor. I am also convinced that these efforts, which must be promoted in every way, will lead to a considerable diminution of tuberculosis. But a long time must elapse ere essential changes can be effected in this direction, and much may be done meanwhile in order to reach the goal much more rapidly.

If we are not able at present to get rid of the danger which small and overcrowded dwellings involve, all we can do is to remove the patients from them, and, in their own interests and that of the people about them, to lodge them better; and this can be done only in suitable hospitals. But the thought of attaining this end by compulsion of any kind is very far from me; what I want is that the consumptives may be enabled to obtain the nursing they need better than they can obtain it now. At present a consumptive in an advanced stage of the disease is regarded as incurable and as an unsuitable inmate for a hospital. The consequence is that he is reluctantly admitted and dismissed as soon as possible. The patient, too, when the treatment seems to him to produce no improvement, and the expenses, owing to the long duration of his illness, weigh heavily upon him, is himself animated by the wish to leave the hospital soon. That would be altogether altered if we had special hospitals for consumptives, and if the patients were taken care of there for nothing, or at least at a very moderate rate. To such hospitals they would willingly go; they could be better treated and cared for there than is now the case. I know very well that the execution of the project will have great difficulties to contend with, owing to the considerable outlay it entails. But very much would be gained if, at least in the existing hospitals, which have to admit a great number of consumptives at any rate, special wards were established for them, in which pecuniary facilities would be offered them. If only a considerable fraction of the whole number of consumptives were suitably lodged in this way, a diminuation of infection and consequently of the sum total of tuberculosis could not fail to be the result. Permit me to remind you in this connection of what I said about leprosy. In the combating of that disease also great progress has already been made by lodging only a fair number of the patients in hospitals. The only country that possesses a considerable number of special hospitals for tubercular patients is England, and there can be no doubt that the diminuation of tuberculosis in England, which is much greater than in any other country, is greatly due to this circumstance. I should point to the founding of special hospitals for consumptives and the better utilization of the already existing hospitals for the lodging of consumptives as the most important measure in the combating of tuberculosis, and its execution opens a wide field of activity to the state, to municipalities, and to private benevolence. There are many people who possess great wealth, and would willingly give of their superfluity for the benefit of their poor and heavily afflicted fellow creatures, but do not know how to do this in a judicious manner. Here is an opportunity for them to render a real and lasting service by founding consumption hospitals or purchasing the right to have a certain number of consumptive patients maintained in special wards of other hospitals free of expense.

As, however, unfortunately, the aid of the state, the municipalities, and rich benefactors will probably not be forthcoming for a long time yet, we must for the present resort to other measures that may pave the way for the main measure just referred to and serve as a supplement and temporary substitute for it.

Among such measures I regard obligatory notification as specially valuable. In the combating of all infectious diseases it has proved indispensable as a means of obtaining certain knowledge as to their state, especially their dissemination, their increase and decrease. In the conflict with tuberculosis also we cannot dispense with obligatory notification; we need it not only in order to inform ourselves as to the dissemination of this disease, but mainly in order to learn where help and instruction can be given, and especially where the disinfection, which is so urgently necessary when consumptives die or change their residences, has to be effected. Fortunately it is not necessary to notify in all cases of tuberculosis, nor even in all cases of consumption, but only those that, owing to the domestic conditions, are sources of danger to the people about them. Such limited notification has already been introduced in various places—in Norway, for instance, by a special law, in Saxony by a ministerial decree, in New York and in several American towns, which have followed its example. In New York, where notification was optional at first and was afterward made obligatory, it has proved eminently useful. It has thus been proved that the evils which it used to be feared the introduction of notification for tuberculosis would bring about, need not occur, and it is devoutly to be wished that the examples I have named may very soon excite emulation everywhere.

There is another measure, closely connected with notification, viz., disinfection, which, as already mentioned, must be effected when consumptives die or change their residence, in order that those who next occupy the infected dwelling may be protected against infection. Moreover, not only the dwellings but also the infected beds and clothes of consumptives ought to be disinfected.

A further measure, already recognized on all hands as effective, is the instructing of all classes of the people as to the infectiousness of tuberculosis, and as to the best way of protecting one's self. The fact that tuberculosis has considerably diminished in almost all civilized states of late, is attributable solely to the circumstance that knowledge of the contagious character of tuberculosis has been more and more widely disseminated, and that caution in intercourse with consumptives has increased more and more in consequence. If better knowledge of the nature of tuberculosis has alone sufficed to prevent a large number of cases, this must serve us as a significant admonition to make the greatest possible use of this means, and to do more and more to bring it about that everybody may know the dangers that threaten him in intercourse with consumptives. It is only to be desired that the instructions may be made shorter and more precise than they generally are, and that special emphasis be laid on the avoidance of the worst danger of infection, which is the use of bedrooms and small, ill-ventilated workrooms simultaneously with consumptives. Of course the instructions must include directions as to what consumptives have to do when they cough and how they are to treat their sputum.

Another measure, which has come into the foreground of late, and which at this moment plays to a certain extent a paramount part in all efforts for the combating of tuberculosis, works in quite another direction. I mean the founding of sanatoria for consumptives.

That tuberculosis is curable in its early stages must be regarded as an undisputed fact. The idea of curing as many tubercular patients as possible in order to reduce the number of those that reach the infectious stage of consumption, and thus to reduce the number of fresh cases, was therefore a very natural one. The only question is whether the number of persons cured

in this way will be great enough to exercise an appreciable influence on the retrogression of tuberculosis. I will try to answer this question in the light of the figures at my disposal.

According to the business report of the German Central Committee for the Establishment of Sanatoria for the Cure of Consumptives, about 5,500 beds will be at the disposal of these institutions by the end of 1901, and then, if we assume that the average stay of each patient will be three months, it will be possible to treat at least 20,000 patients every year. From the reports hitherto issued as to the results that have been achieved in the establishments, we learn further that about 20 per cent of the patients that have tuberclebacilli in their sputum lose them by the treatment there. This is the only sure test of success, especially as regards prophylaxis. If we make this the basis of our estimates, we find that 4,000 consumptives will leave these establishments annually as cured. But, according to the statistics ascertained by the German Imperial Office of Health, there are 226,000 persons in Germany above fifteen years of age who are so far gone in consumption that hospital treatment is necessary for them. Compared with this great number of consumptives, the success of the establishments in question seems so small that a material influence on the retrogression of tuberculosis in general is not yet to be expected of them. But pray do not imagine that I wish, by this calculation of mine, to oppose the movement for the establishment of such sanatoria in any way. I only wish to warn against the over-estimating of their importance which has recently been observable in various quarters, based apparently on the opinion that the war against tuberculosis can be waged by means of sanatoria alone, and that other measures are of subordinate value. In reality the contrary is the case. What is to be achieved by the general prophylaxis resulting from recognition of the danger of infection and the consequent greater caution in intercourse with consumptives is shown by a calculation of Cornet regarding the decrease of mortality from tuberculosis in Prussia in the years 1889 to 1897. Before 1889 the average was 31.4 per 10,000, whereas in the period named it sank to 21.8, which means that, in that short space of time, the number of deaths from tuberculosis was 184,000 less than was to be expected from the average of the preceding years. In New York, under the influence of the general sanitary measures directed in a simply exemplary manner by Biggs, the mortality from tuberculosis has diminished by more than 35 per cent since 1886. And it must be remembered that both in Prussia and New York the progress indicated by these figures is due to the first beginnings of these measures. Considerably greater success is to be expected of their further development. Biggs hopes to have got so far in five years that in the city of New York alone the annual number of deaths from tuberculosis will be 3,000 less than formerly. I take this opportunity of most urgently recommending Dr. Biggs' organization to the study and imitation of all municipal sanitary authorities.

Now, I do indeed believe that it will be possible to render the sanitoria considerably more efficient. If strict care be taken that only patients be admitted for whom the treatment of those establishments is well adapted, and if the duration of the treatment be prolonged, it will certainly be possible to cure 50 per cent, and perhaps still more. But even then, and even if the number of the sanatoria be greatly increased, the total effect will always remain but moderate. The sanatoria will never render the other measures I have mentioned superfluous. If their number become great, however, and if they perform their functions properly, they may materially aid the strictly sanitary measures in the conflict with tuberculosis.

If now, in conclusion, we glance back once more to what has been done hitherto for the combating of tuberculosis, and forward to what has still to be done, we are at liberty to declare with a certain satisfaction that very promising beginnings have already been made. Among these I reckon the consumption hospitals of England, the legal regulations regarding notification in Norway and Saxony, the organization created by Biggs in New York, the sanatoria, and the instruction of the people. All that is necessary is to go on developing these beginnings; to test, and, if possible, to increase their influence on the diminution of tuberculosis, and wherever nothing has yet been done, to do likewise.

If we are continually guided in this enterprise by the spirit of genuine preventive medical science, if we utilize the experience gained in conflict with other pestilences, and aim, with clear recognition of the purpose and resolute avoidance of wrong roads, at striking the evil at its root, then the battle against tuberculosis, which has been so energetically begun, cannot fail to have a victorious issue.

An electric elevator has been installed in the Washington Monument. It carries thirty-five passengers, and the car weighs about two tons. An ascent of 498 feet is made in five minutes.

THE "ELECTRICIA" CARRIAGES.

THE electric carriage is without doubt the ideal automobile as regards the facility of starting and maneuvering, cleanliness, safety and absence of noise, vibrations and odor.

No other system can now be compared to it as a city and outing carriage. It is even to be hoped that in consequence of the progress made in the construction of accumulators and of the increase in the number of charging stations, the electric carriage may, in the near future, be applied to touring, and enter into serious competition with gasoline vehicles.

Still, it may be said that even now the field of application open to electric carriages is sufficiently vast to justify the uninterrupted researches and labors to which they are giving rise.

We now find in the market all the parts (motors, transmitters, steering gear, accumulators, etc.) that may be employed for mounting an electric carriage, and many manufacturers are using them or have always extensively used them, and for this reason there are few vehicles of this kind that offer peculiarities of interest.

The manufacturers who are endeavoring to perfect the different parts and thus create types which, while original with them, show a perceptible improvement upon what already exists, are few.

An exception to this statement, however, may be made in regard to the "Electricia" carriages constructed, complete in all their parts, by M. C. Contal, and in which the motor, the transmitters, the steering gear and the accumulators have been especially elaborated and present very interesting advantages that augur well for the future of this system.

Three types of carriages are at present constructed: a victoria, a phaeton and a "duc-tonneau."

The victoria, as shown in Fig. 1, has a very elegant form. It is a perfect and comfortable type of the city carriage. It is provided with seats for six persons inclusive of the driver, and weighs but 2,310 pounds in running order. The 5 horse power motor and the accumulators are ingeniously concealed. The length of run possible varies from 50 to 62 miles according to the ground and the number of passengers carried.

The phaeton represents the long-trip pleasure vehicle. It carries 2, or, with the removable back seat, 4 persons; weighs 2,618 pounds in running order, and is designed to cover 80 to 88 miles without a recharge.

The tonneau is a type of the family carriage, and presents a form which is in much esteem just now. The motor, as in the phaeton, is of 8 horse power.

All these carriages run admirably well, consume 70 watt-hours on a level at a speed of 12.5 miles an hour, and climb all hills with a very small expenditure of power, by reason of the very high efficiency of the driving parts as a whole. The electric motor (Fig. 5) which was elaborated by M. Contal in conjunction with M. P. Gasnier of the School of Physics and Industrial Chemistry of Paris, is specially combined for propulsion, and its form is entirely different from that of the usual motors. It is cuirassed and hermetical, of a feeble weight although of high efficiency, and has two armature and two inductor windings. This permits, through coupling, of causing the speed to vary within wide limits without it being necessary to change the coupling of the accumulators, which, always working in series, are placed in a better and more efficient operative condition. This motor is characterized by the new arrangement of the inductors and induction coils, which permits (1) of integrally utilizing the entire inductor discharge, (2) of almost wholly suppressing the reaction of the armature, (3) of reducing the space occupied by and the weight of the motor, and (4) of rendering easy the cleaning and inspection of the brushes and collector, the removal of the armature and, if need be, the dismounting of the inductors. The weight of the motor is 211 pounds for a continuous normal 8 horse power.

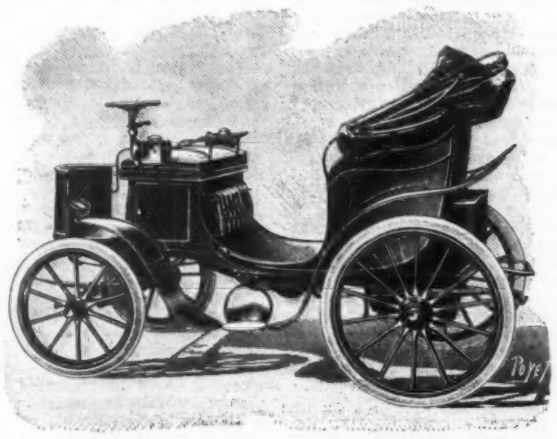


FIG. 1.—GENERAL VIEW OF "ELECTRICIA" VICTORIA.

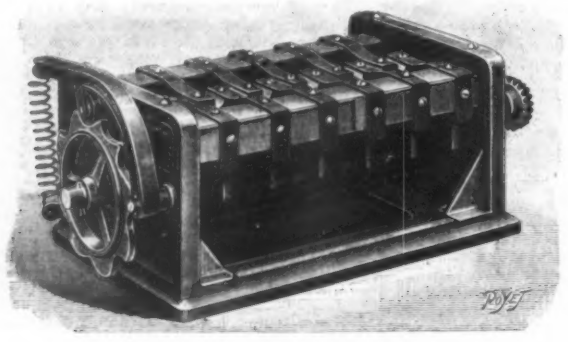


FIG. 2.—CONTROLLER.

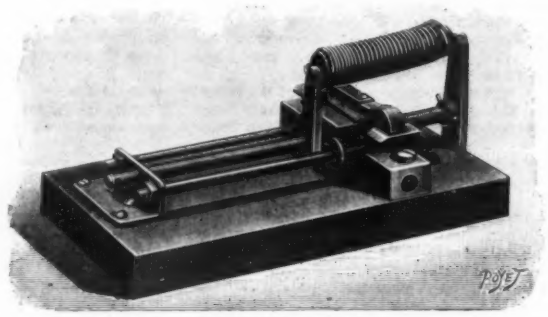


FIG. 3.—PEDAL INTERRUPTER.

The motor is employed with the three following couplings: (1) The two inductors in tension grouped in series with the two armatures in tension; (2) the two inductors in quantity, grouped in series with the two armatures in tension; (3) the two inductors in quantity, grouped in series with the two armatures in quantity.

The figures of the efficiency corresponding to these three couplings are as follows:

	Greater than 80% between.	Greater than 85% between.	Maximum.
	Amperes.	Amperes.	Amperes.
Coupling 1.....	12 and 38	....	84% at 20
" 2.....	14 and 68	20 and 45	86.6% at 30
" 3.....	27 and more than 15)	40 and 90	80% at 60

Now as regards propulsion, since the mean efficiency

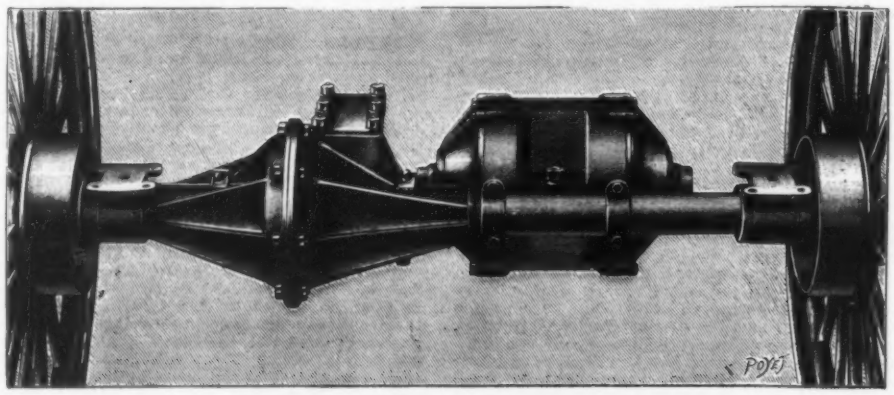


FIG. 4.—AXLE PROVIDED WITH ELECTRIC MOTOR.

alone, and not the maximum, has to be taken into consideration, in consequence of the continual and great variations in the charge of the motors, two points of the most important character are to be remarked in the results obtained; on the one hand, the high value of the efficiency, and, on the other, its slight variation under very variable charges. The motor is formed integrally with the motor axle (Fig. 4), which oscillates around pieces that connect it with the carriage springs. In front it is suspended from the frame by springs that deaden the effects of starting, changes of speed and braking.

The transmission is effected entirely through gearings, and the hind axle consists solely of two tubes

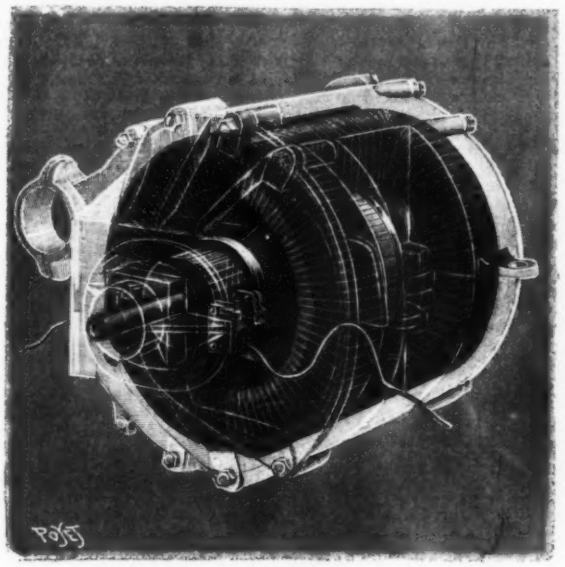


FIG. 5.—ELECTRIC MOTOR.

assembled by a case in which the gearings are housed. The extremities of the tubes form the journals of the wheels, the hubs of which are controlled by the shafts of the differentials. These shafts pass into the interior of the tubes and thus work only by torsion, while the external tubes, which really form the axle, work only by flexion. We have thus a non-distortable hermetical motor capable of operating in any weather, and of being washed with a copious amount of water without any inconvenience.

A peculiar system of lubrication rationally oils all the rubbing parts, and the same oil, perfectly protected from dust, may be utilized for a very long time. The motor is secured to the carriage by eight bolts, which it suffices to unscrew in order to remove it entirely.

The steering shaft, which is generally inclined, is provided with a hand wheel and is irreversible. The mechanism is very simple and is constructed with a view to avoiding the rapid wear that usually occurs with irreversible steering shafts in which an endless screw engages with a toothed sector. Here the endless screw engages with a nut of which the rectilinear motion is converted, through a watt parallelogram, into a circular motion that permits of the control of the wheels. As the surface of contact of the screw with the nut that it controls is much wider than in steering shafts with a toothed sector, the wear is much less rapid.

The controller (Fig. 2), which is actuated by a handle placed immediately beneath the steering hand-wheel, is of very simple construction, and gives five speeds forward, an inoperative position, two electric brakings and a backward motion. The forward speeds are 5, 6.8, 10, 13 and 16 miles an hour. The electric brakes are so combined that the breakages of the circuit of an armature or an inductor, or even of both at once, does not prevent the braking from taking place. The mechanical brakes act upon both the front and rear of the two driving wheels. By means of a special interrupter (Fig. 3) the current is automatically broken through a simple pressure upon the brake pedals. The accumulators are pasted oxide ones and are distinguished by their construction, which is effected wholly by machinery. All the plates are by this fact identical in form, weight, porosity and consistence. They work equally in all their parts, and this greatly diminishes their disintegration and permits them to resist charges and discharges at excessive rates. The capacity obtained is very high, as shown by the tests at various charges made at the Central Laboratory of Electricity. The element submitted to the tests was of 21 plates and weighed 28.8 pounds. It gave a capacity of 194 ampere hours for a discharge of 5h53 corresponding to a specific energy of about 15 pounds per total pound.

The driving of the "Electricia" carriages is one of the easiest matters. The number of the parts to be maneuvered is reduced to a minimum: (1) a hand-wheel for the steering, which is irreversible; (2) a single handle under the hand-wheel for forward running, backward running and electric braking; and (3) a circuit-breaking brake-pedal for quick stoppages. As may be seen, the different parts of the carriage have been carefully elaborated with a view to creating an *ensemble* of which the parts should be well in place, easily accessible and kept in repair and replaced, and give a maximum of efficiency with a minimum of cost of maintenance.—For the above particulars and the engravings we are indebted to La Nature.

A SHALLOW DRAUGHT STEAMER FOR MISSIONARY WORK IN THE CONGO.

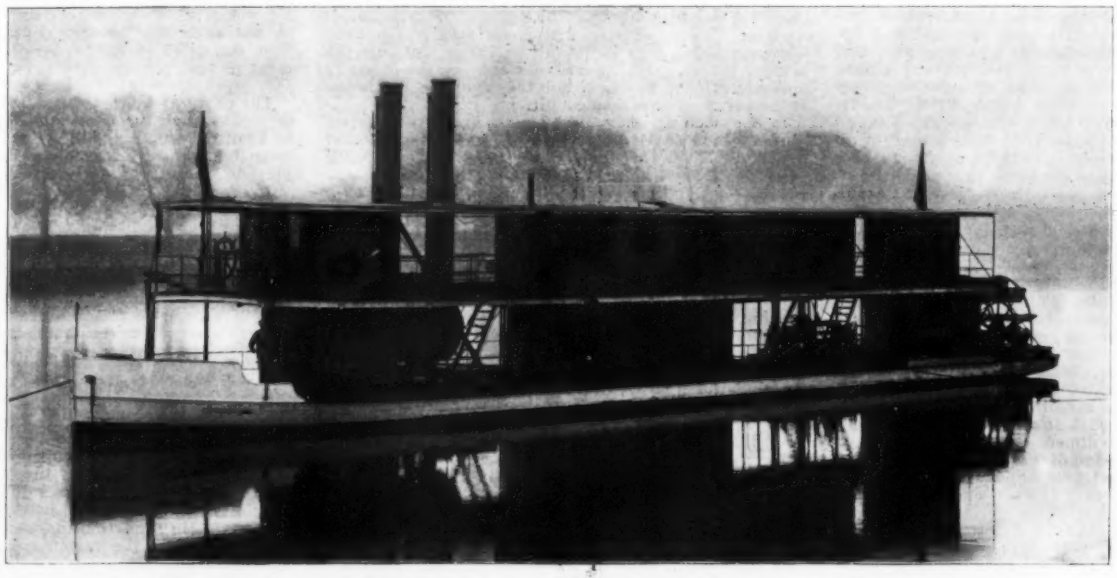
THE Missionary Union of London, to facilitate their work in the Upper Congo, West Africa, are requisitioning a stern-wheel shallow-draught steamer, similar in design to those utilized upon the upper reaches of the Nile in Egypt. This is the first occasion upon which one of this type of boat has been employed for this purpose, and she has occasioned considerable interest. The vessel, which is christened "Livingstone," in honor of the great explorer who passed so much of his time in this part of the African continent, has been constructed by Messrs. John I. Thorneycroft, of Chiswick, London. It measures 111 feet over all, has a beam of 19 feet 3 inches, and her draught when carrying a load of 20 tons is only 2 feet 6 inches. Owing to the impossibility of obtaining coal in the region in which she is to ply, wood will be utilized for fuel, and her speed with full load on board is 11 miles per hour.

The vessel is provided with two decks. The main deck is chiefly reserved for the boilers and engines. The former, which are of the locomotive type, are placed forward. They are of large size, with a steam pressure of 130 pounds per square inch, and 200 I. H. P. The engines for driving the stern wheel are placed aft. They are of the compound non-condensing type, with cylinders 17 inches and 28 inches in diameter, respectively, and a stroke of 48 inches. In the center of the vessel, on the same deck, are located the crew's quarters, cooking galley, and hospital dispensary.

Right forward on the upper deck is placed the steering wheel and the captain's cabin. The sleeping cabins, dining saloon, hospital, bathroom and lavatories are also placed on this deck. The hospital has accommodation for nine patients and is comfortably fitted up. The saloons and cabins are also well furnished, in order to render them as homelike as possible. The woodwork throughout the vessel is executed in teak, and owing to the pestilential nature of the country to which the craft is destined, all the windows to the cabins are fitted with mosquito-proof gauze panels.

On top of the awning deck, amidships, a large water tank is placed to supply the water for the baths, lavatories, etc. The tank is filled by a donkey pump. The baths are heated by steam. A wide promenade extends right round the vessel on both decks, and there is sufficient open space for accommodation of freight.

The total cost of the vessel was $28,150. The boat is to be taken to pieces, and shipped in sections to Matadi. From there it will be transported over the New Congo Railroad to Stanley Pool, where it will be reconstructed and relaunched. The cost of transshipment and reconstruction alone will amount to $15,000.



SHALLOW-DRAUGHT STERN WHEEL STEAMER "LIVINGSTONE", FOR THE CONGO.

AMERICAN LOCOMOTIVES IN ENGLAND.—I.

By A LOCOMOTIVE ENGINEER.

IN view of the "hubbub"—if I may so express it—caused by the importation, some two years ago, of American locomotives by several English railway companies—an event which was heralded by the American press as evidence that American locomotive makers could deliver in this country engines of equal power with English-made engines at considerably lower price, the prices charged by the American firms being a few hundred pounds per engine less than that of British firms, and which event was consequently regarded by some of the non-technical press at home and abroad as the death-knell of the British locomotive industry—it is not surprising that the facts recently communicated to the Daily Mail by the Midland Railway authorities, as to the marked disadvantage of the American engines, as a result of their trial of the two makes of engines in question, should cause widespread interest, and incite the active minds and fluent pens of "those who know" to explain to the world in general, and to the "superficial thinker" in particular, the true import of the Midland Railway trials.

Among the first in the field was Mr. Rous-Marten, whose article on the subject, in defense of the American locomotive, was published in the SCIENTIFIC AMERICAN SUPPLEMENT of July 6.

The very fact that locomotive users in the position of the Midland Railway Company should have instituted trials between English and American engines, and given the results of their experience to the press, invests the subject with an importance which cannot be gainsaid. It may be that the figures published by the railway company are lacking in the detail which would be necessary to enable the whole question to be exhaustively treated, and it would, no doubt, be open to those whose desire or interest it may be to take up the cudgels in defense of the American locomotives to claim the need for fuller details before the pronouncement of a final verdict on the question of British *versus* American locomotives as raised by the trials on the Midland Railway.

This is a point, however, which Mr. Rous-Marten does not think requisite to raise. On the contrary, he says: "I need hardly say that I implicitly accept Mr. Johnson's figures, and that I am perfectly satisfied as to his desire to make the comparison as fair as possible." Nor does he question the fairness of the conditions under which the trials were made, for further on he adds: "I simply say that while on the whole no exceptions can be taken to the fairness of the methods adopted for trying on the Midland Railway

those two different classes of its own engine (*sic*), such a trial affords no test whatever of the relative merits of British and American locomotives, or methods of locomotive practice." He further says: "My sole criterion of merit is its—the locomotive's—performance in relation to its requirements, its conditions, and its nominal power."

I accept Mr. Rous-Marten's statement of the case as thus enunciated, but when one comes to consider the arguments by which he seeks to explain away the unfavorable position in which the published figures place the American engines, one feels impelled, in the interests of that "truth, fairness and science" which Mr. Rous-Marten is seeking to promote, to call in question the soundness of his contentions.

The statement issued by the Midland Railway authorities was as follows: "Extra working cost of American engine over English engine: Fuel, 20 to 25 per cent; oil, 50 per cent; repairs, 60 per cent." Now, how does Mr. Rous-Marten endeavor to dispose of these damaging figures against the American engines—made by two of the best-known firms in the United States, after six months' trial against British-made engines of the same power and doing the same work?

He starts by laying down the astonishing premises that although the Midland Railway Company, when ordering the American engines in question, specified that they "were to be of the same power as the standard Midland goods engine"—against which they were tried—it is nevertheless not "a fair comparison to have both engines made as nearly as possible of practically identical power, and then to try them together on identical work, unless it be clear that each class of engine is the one that would be used in the land of its origin." And why? Mr. Rous-Marten replies as follows: "For such duty in the United States locomotives of far greater power would be used than these, which have only 1,214 to 1,364 square feet of heating surface, 160 pounds steam pressure, and cylinders 18 inches by 24 inches, with 5-foot coupled wheels." Mr. Rous-Marten evidently feels this explanation to be not entirely conclusive, for he proceeds to add: "It may reasonably be asked, 'Why, if the smaller dimensions suffice for the British engine, should they be insufficient for the American?'" This query is an obvious and reasonable one. Let us see what Mr. Rous-Marten's rejoinder is. It is as follows: "The reply is that all American locomotive practice is based on the principle of allowing a margin of power." On this point I need only say, in passing, that the giving of a margin of power is such a well-known, long-established principle in all engine designs—and not confined to American locomotive practice—as to go without saying. The important and practical question in all such cases—and especially as regards a locomotive engine which has to propel itself in addition to its load—is, of course, how much, or, rather, how little, margin of power, which spells weight, is necessary to insure success? Leaving this for the moment, however, I proceed with Mr. Rous-Marten's remarks: "In all classes of work this is the rigid American rule, and, in pursuance of that rule, I assert, with considerable experience of American practice in various parts of the globe, that had the American builders been instructed to supply an engine to do certain specific duty, they would not have produced the type now seen on a few British railways, but one of far greater power. And, therefore, as the American locomotives have worked under conditions not suitable to their type, they necessarily have worked under a serious disadvantage."

I think I have already sufficiently illustrated the line of argument pursued by Mr. Rous-Marten in defense of the imported American engines. I fear, however, that I might lay myself open to the charge of vitiating his argument by omitting his succeeding explanations. I will therefore, at the risk of needless quotation, proceed with Mr. Rous-Marten's remarks, as follows:

"For when you try one locomotive which is specially designed on the spot for particular work against another built in a different country on a different design, and brought into comparison merely as possessing approximately identical dimensions, you handicap the latter very adversely. Virtually, you pit an engine, admittedly and specially suitable to its prescribed duty, against one which, while nominally of nearly equal power, is practically much less strong, because its type and design presuppose it to have a margin of strength which, under these conditions, is absent, and because also its type is only employed in its country of origin, for the specified work, with greatly larger dimensions." And he then adds: "Therefore the Midland trial only proves that identical dimensions for identical work will not suit engines of totally different designs and modes of construction."

One is at a loss to know which of the several specious arguments in the foregoing quotations to deal with first. They have been detected and dealt with more or less already in the letters published in the Scientific American Supplement. I may start, however, by pointing out one obvious deduction which follows from this contention that, in order to place the American locomotive on a footing rendering it fairly comparable with the British engine in doing the same duty, it must be made to dimensions giving it a higher margin of power than that of the British locomotive. I think the non-technical press, and even the "superficial thinker" alluded to by Mr. Rous-Marten, will spontaneously perceive that, if the course suggested by him had been followed by the American locomotive builders in this instance, their engines would have cost more in proportion to their larger size. Probably more than the difference in price between them and the British engines, which is stated by the Midland Company to have been only £400 each, which would have precluded the contention put forward at the time by the pro-American press, that American locomotive builders could deliver in this country locomotives of equal power with British locomotives at a considerably lower price. Mr. Rous-Marten's arguments appear to effectually knock this fallacy on the head.

But, in the next place, American engines, with their greater margin of power than the British engines, would weigh more, and this extra weight would have to be rolled up and down the line, to the detriment of the permanent way, without effecting any better results than the lighter English engines. Besides, Mr. Rous-Marten does not attempt to show how the use of larger engines would tend to lessen the consumption of fuel and oil, in which respect the American engines already compare so unfavorably with the English engines, although possibly the cost of repairs might be somewhat reduced by the adoption of a greater margin in the wearing surfaces, in which the American type of engine is often conspicuously deficient in comparison with English practice. But, after all, what is to be gained in the interests of either truth, fairness or science by any such line of argument as that attempted by Mr. Rous-Marten? It is, or ought to be, obvious to all—even to the "superficial thinker"—that the best type of locomotive, as regards both general design and modes of construction, and from a scientific as well as a practical point of view, is the one which secures efficient and reliable working of the stipulated load with the least margin of power compatible therewith, and at the least expenditure of money in respect of fuel, oil and repairs. The trial of American and British locomotives on the Midland Railway gives the palm in favor of the British engines, notwithstanding all that Mr. Rous-Marten has so far advanced to the contrary.

If Mr. Rous-Marten's theory were a sound one, I feel convinced that the experienced American locomotive builders who furnished the engines in question would have taken care, when negotiating with the Midland Railway Company for the supply of engines of the same power as the Midland standard goods engines, to see to it that their engines possessed the requisite extra dimensions. I think, therefore, that some other reason than the one Mr. Rous-Marten suggests is needed to explain the very unfavorable result of the trials of the American engines on the Midland Railway. It will be interesting to learn what the makers of these American locomotives have to say in explanation.

The subject, as I have said, is a many-sided one, raising a variety of points. These I purpose to deal with in a subsequent communication.—The Engineer.

SCHOOL ROOM TEMPERATURE AND HUMIDITY.*

If we contend that the march of human progress finds its inception and stimulus in the school room, it is only reasonable to hold that the school room should share in the trophies acquired by the intellectual warrior in the field of science, art and letters. The school house, in accordance with its own necessities, is entitled to all that human thought has achieved. In order that it may continue to fulfill its mission to the highest degree, the school house can make a just claim to the best devices invented by man.

We have reached a period where the school house has become more than a mere gathering center or a shelter against the elements. We have come to recognize that its very walls are a factor in the educational growth of the child. The structure no longer merely houses the children, but it has become a huge educational device as well. It adapts its appointments in order that they may bear the largest educative influence upon the inmates and also protect their physical welfare as a pre-requisite to intellectual advancement.

Until a few years ago the essentials of a school house were few. To-day we discriminate between a variety of systems of heating devised by able engineers. Ventilation has been reduced to an exact science. School room lighting is thoroughly understood and correctly applied.

In drawing comparisons between the old and the new school house, some school-board members are apt to lapse into the belief that the crude structure of former days, with its meager equipment, would suffice to-day. Others will reason that too much goes into the modern school house.

One might as well argue that the wooden plowshare of ancient times will serve as well as the steel plow of to-day, or that a tallow candle will shed as much radiance as an electric light. The boy of to-day requires a better mental equipment for the battle of life than did our forefathers. The general progress in all lines of human activity will make greater demands upon the young man of the future. Thus, not only the modern school, with its well devised courses of study and educational methods, but the whole school house is the result of advanced conditions.

In approaching my subject I must first of all correct an erroneous impression which exists in the minds of a portion of the school public. One of the peculiar features which has developed in my inquiry on temperature regulation in school houses is the tendency to confound it with another subject.

It would seem unnecessary to explain that heat regulation pertains entirely to a system by which the temperature is controlled against excessive heat or excessive cold. It would seem equally unnecessary to explain specifically that ventilation pertains to the induction of fresh air and the removal of foul air.

While every one knows this, we find many school officials who do not differentiate temperature regulation from ventilation. No doubt if asked point blank to define the difference between temperature regulation and ventilation a correct answer would be received in each instance. It is not ignorance, but thoughtlessness, that causes the misconception.

It is one thing to provide a class room constantly with fresh air; it is an entirely different thing to so regulate that the air is neither too warm nor too cold. Thus, let us bear in mind the wide difference between ventilation and temperature regulation.

A discussion of the subject of temperature regulation can only result in beneficial results. If school officials have hitherto occupied their minds with the various kinds of heating systems to the exclusion of temperature regulation, it is because the latter has not been urged upon them with any considerable pressure. A busy set of men—busy in their several vocations in life—do not always find it convenient to give the time necessary for a thorough study of all the things that ought to go in or about a school house.

In the modern school house artificial heat need no longer be measured out extravagantly or penuriously to the discomfort or danger of its inmates. It can be placed under automatic control by simple devices—insuring economy and protecting the health of the inmates.

In attempting to say something about temperature regulation, as applied to school houses, I may be pardoned if I assume that a scientific discussion is neither in place nor desirable. Hence, I will treat the subject in an elementary form.

An even temperature at a certain degree is conducive to the growth of plant and animal life. Vegetable and animal foods owe their prolonged preservation to an even temperature.

An apple picked in October of last year and found in fine flavor and juice in the month of June this year, owes its wonderful preservation to nothing else but an even temperature. The qualities of the apple have been prolonged by the control of natural elements. In the same manner has the growth of the strawberry which reaches the market in the month of January been hastened by surrounding it with a temperate atmosphere. Temperature extremes hasten the death of both plant and animal life.

It may be claimed that a variation of temperature is conducive to hardihood. Under certain conditions, yes. A child may withstand extreme cold while engaged in healthful exercise. Under certain conditions extreme heat may be borne without injurious effects. When the body, however, is inactive, a variable temperature is harmful. Thus an over-heated, as well as an under-heated school room, may do incalculable injury to the child.

The automatic control of school-room temperature involves, primarily, the question of finance. The great majority of school houses in the United States require artificial heating during seven months in the year. The fuel expense in cities and towns where large buildings must constantly be kept warm, is a heavy one. The consumption of fuel is steady and constant during certain periods of the year—continuing year after year. Thus, any slight daily reduction in fuel consumption may prove a considerable saving at the end of a month or a year. The saving of a *few hundred dollars* in the purchase of a school site or the erection of a school building offers *no comparison* with the aggregate saving accomplished in a *daily reduction of the fuel expense.* Every degree of excess heat represents that much waste.

Temperature regulation in the school room, however, is a simple proposition. It requires no expert mathematician to measure its material advantage, nor a medical expert to determine its hygienic qualities. A few things need only be considered. If the outdoor temperature is 50 deg., and the school temperature should be 70 deg., only 20 deg. of artificial heat is required to make the school room comfortable. Consequently the fuel expenditure should cover 20 deg. only. That which goes above this is waste and consequently extravagance. An open window to cool off an overheated room is an unwarranted exposure of the school occupants to coughs and colds which may lead to serious results. No school board has the right to endanger the physical comfort and welfare of pupil or teacher.

But let us get back to the expense item again. The fuel expenditure should cover only the difference between the outdoor and indoor temperature. This may vary all the way from zero up. Variation may be constant. The most attentive janitor will miss his firing by several degrees of the temperature desired or required. In the forenoon the outdoor temperature may be 40 deg., in the afternoon 50 deg. Consequently 30 deg. of artificial heat are required in the forenoon, and only 20 deg. in the afternoon. The janitor may anticipate the change in temperature. The chances are that he does not. The surplus heat has either escaped through the chimney with the janitor's aid, or through the school room window with the teacher's aid. A well-adjusted mechanical device would regulate the temperature from minute to minute without human aid, and regulate the fuel consumption accordingly. Even a few degrees of excess heat will make a vast difference in the aggregate of fuel consumption for the year. This stands to reason. Therefore an *accurate* adjustment of fuel *consumption* must effect a saving in *the fuel expense.*

The physical welfare of the teacher and pupil cannot be treated as a secondary consideration. In fact, if it is admitted at all that hygiene is a factor in school room temperature, it follows that it is one that must precede monetary considerations. Therefore, if it will effect an actual saving in dollars and cents, sufficient to pay its installment in a few years, the advantage is a double one. Were this not the case, the hygienic proposition involved would alone be sufficient to warrant a recognition of the advantage derived from a heat-regulating device.

It is not my purpose here to champion any one system of automatic temperature regulation. There are several systems on the market, some of which are all that could be expected of them, while others are worthless.

The subject of atmospheric humidity or air moisture and its relation to the human system has thus far received little or no attention at the hands of school authorities. While the subject is an important one, but little data has been collected. The scientists who have entered this field of investigation contend, however, that for certain classes of invalids the prevailing humidity at a given point is of more consequence than the variability of the temperature, no matter how sudden or sharp the variation may be. Yet, it is held that medical literature is almost entirely lacking in a scientific explanation of the effect of the different degrees of humidity upon the animal economy.

Dr. W. M. Wilson, director of the United States Weather Bureau, who has given the subject careful study, says:

"It is safe to assume that during the winter months the normal relative humidity in lake cities is 72 per cent and the average diurnal range is from 60 to 72 per cent. From observations with respect to moisture in business offices and living rooms heated by steam, hot water and hot air, it is safe to assume that the average relative humidity in artificially heated dwellings and offices in the winter months is about 30 per cent, or about 42 per cent less than the average outside humidity, and drier than the driest climate known.

* Address by William George Bruce, Editor American School Board Journal, delivered before the Department of School Administration, N. E. A., Detroit, June 10, 1901.

"The evaporation power of the air at a relative humidity of 30 per cent is very great, and, when the tissues and delicate membranes of the respiratory tract are subjected to the drying process, a corresponding increase of work is placed upon the mucous glands in order to keep the membranes in proper physiological condition. Nature in her effort to compensate for the lack of moisture in the air is obliged to increase the functional activity of the glands, and this increase of activity and the frequent unnatural stimulation, induced by the changing conditions of humidity from the moisture-laden air outside to the arid atmosphere inside our dwellings, finally results in an enlargement of the gland tissues, on the same principle that constant exercise increases the size of any part of the animal organism. Not only do the glands become enlarged, but the membrane itself becomes thickened and harsh, and sooner or later the surface is prepared for the reception of the germs of diseases, which tend to develop under exposure to the constantly changing percentage of humidity."

The medical authorities tell us that the "physiological symptoms of an atmosphere too dry are parched lips and tongue, a dry feverish condition of the skin, and, in those children predestined to lung disease, a hacking cough, resulting from the desiccating effect of excessively dry air on the lungs and bronchial tubes."

A mummified and shrivelled appearance of the human skin is caused by a dry atmosphere. The ruddy complexion and red cheeks of English men and women is due to air moisture. The importance of aqueous vapor as a constituent in our atmosphere was not exaggerated by Tyndall, when he startled the scientific world by the announcement: "The removal, for a single summer night, of the aqueous vapor from the atmosphere which covers England, would be attended by the destruction of every plant which a freezing temperature could kill."

On the economy of fuel consumption achieved by controlling humidity in the school room I can do no better than to quote Director Wilson. He says:

"A humid atmosphere is economical. In a room in which the temperature is 72 deg., the temperature of the wet-bulb is 54.5 deg. If a room with a sensible temperature of 54.5 deg. is considered comfortable, the same result can be attained by heating to only 60 deg., and supplying sufficient moisture to raise the humidity to 70 per cent, which still conforms very closely to the normal condition of the outside air, so far as moisture is concerned. It would probably be impracticable to maintain uniformly a relative humidity of 70 per cent, especially with a low outside temperature, as the condensation upon the windows would be undesirable; but by heating to 65 deg. the relative humidity could be held at 50 per cent without any ill effects, except possibly on extremely cold days. Competent engineers estimate that about 25 per cent of the cost of heating could be saved by holding the temperature at 60 deg. and raising the humidity to 70 per cent, still maintaining a wet-bulb temperature of 54.5 deg., the same as that obtained by heating to 72 deg. under ordinary conditions. But to be conservative and avoid the possibility of any unpleasant results from condensation, our dwellings could be heated to 65 deg. with a relative humidity of 50 per cent and still save from 12½ to 15 per cent over the present cost."

Here, perhaps, it ought to be explained why humidity will permit a lowering of the temperature without discomfort to the body. With a dry atmosphere the evaporation of the body is stronger than it is in a humid atmosphere. Consequently we feel cooler in a dry than in a moist atmosphere of the same temperature.

The question which would naturally arise in a discussion of this subject would be whether humidity can be brought under mechanical control. Or rather, can atmospheric moisture be supplied artificially to the extent that it may be desired? The need of a larger quantity of moisture in school houses heated by artificial means is recognized, but the difficulties encountered in solving the problem have, it is claimed, largely deterred practical research in this direction.

But here the triumph of the scientist must again be recorded. Recognizing that a humidifier is as necessary to a first-class heating plant as is a temperature regulator, the inventive mind has also brought atmospheric moisture within automatic control and regulation.

Thus, without going over the entire range of modern construction and maintenance of school houses, it may reasonably be assumed that the same energy and study which has brought about wondrous changes in other branches, has also been directed toward perfecting the school house, making it modern in all that the word implies. It remains for the authorities who govern the practical affairs of the American schools of the present day to avail themselves of the achievements of the human mind.

If education is the mainspring of progress, the school room is an elementary workshop. It ought to be a reflex of that progress in all its own appointments. If the school room implants the seeds for useful human activity, its own environments ought to, in keeping with its demands, enjoy the blessings of that activity.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Packing Goods for Export.—Most United States goods sold in this district (Gera) are furnished by the large importing or commission houses at Bremen and Hamburg, whence they are forwarded by rail; the remainder is bought from wholesale houses at Berlin and Leipzig, the nearest centers of trade to Gera. Canned fruits, lard, bacon, hams, petroleum, resin, clover seed, stoves, typewriters, bicycles, sewing machines, apples, hardware, wood specialties, and agricultural machines are the chief articles of American manufacture that find a market in this part of Germany.

Railroad transportation, as far as protection of goods against damage is concerned, is satisfactory; in promptness, however, it is inferior to that of the United States. The storage warehouses are in excellent condition, and injury from the elements is a rare occurrence. The facilities for handling shipments are fair, and although much time is lost by impractical and unsystematic methods, it must be admitted that great care is taken to avoid damage. The laws on this point are very severe, and negligence is promptly censured.

Naturally, a great deal depends upon proper packing, and as this question is an important factor in the development of our foreign trade, the following information will no doubt prove of interest to American exporters.

In most European countries, great attention is given to good packing, as no matter how excellent the goods, they are sure to lose in value if badly put up. For dress goods, which form the bulk of the exportations from this district, strong boxes are made to hold a certain number of pieces. The goods are then packed in firmly, each piece being wrapped in strong glazed paper. The box itself is lined with oiled paper, so as to preserve its contents from dampness, and strapped with iron bands. Great stress is laid on durability and neatness, and old boxes are never used. For shipment to Africa and Australia, the pieces are wrapped in oiled paper and the cases lined with tin. The tin is carefully soldered to make it weather-tight. Merchandise packed in this manner may be sent to the most distant countries without damage. By some manufacturers, the covers of the boxes are fastened with screws to prevent theft. Nothing is neglected to insure arrival in good condition, and the neat and substantial way in which the goods are packed cannot fail to make a favorable impression upon the purchaser.

In making shipments to Europe, our exporters should wrap their goods so as to exclude moisture, and pack them in strong wooden boxes. The boxes should be nailed with wire nails and strapped with iron bands. Goods in bales should be securely wrapped in oilcloth lined with paper, to prevent its adhering to the contents, and covered with strong canvas. The bales should then be pressed and hooped with iron. Economy of space is an important consideration. Special care should be taken by our manufacturers to wrap articles of cast iron so as to avoid shifting. On account of careless packing, goods of this class frequently arrive here either broken or rusty. The bottoms of the cases should be well fastened. Care is also necessary in driving nails, which are often found to have penetrated and damaged the contents of the boxes. Considering the distance the goods are transported and the amount of handling they receive, the packing is often sadly inadequate. As an illustration of this, a number of large American stoves were ordered by a local merchant, and upon their arrival some of them were badly broken and many of the smaller attachments—such as screws, knobs, etc.—missing. The stoves were packed in crates weighing over 400 pounds, which made careful handling impossible. The attachments, including the heavy lids, were put in the ovens loose, and shifted noisily about whenever the crates were moved. Of course, all orders were canceled.

Regarding our preserved fruits, I have been told again and again that they would sell much better if put up in glass bottles, even if the prices were a little higher. There is a great deal of prejudice against tinned goods, as it is believed they might be poisonous. Boxes of canned fruits should be banded with iron. The pine boxes used are not equal to the treatment to which they are subjected, and sometimes arrive in a poor condition.

Another American article which lacks the necessary care in packing is resin. The excuse that this article is very cheap, and for that reason does not warrant better packing, is not valid. Cheap packing in the long run is the dearest, owing to the losses sustained, while care in this respect will do much to enhance the value of an article in the eyes of the foreign purchaser.

I could name a number of other articles with the packing of which fault is found, but it is unnecessary. Suffice it to say that good packing of all kinds of American merchandise will tend to materially increase our export trade. It is conceded that our manufactures are superior to all others, and we need only to correct these minor faults to render our position in the mercantile world unassailable.—Charles Neuer, Consular Agent at Gera.

French Opening for Spraying Machines.—Referring to my report on the decrease of olive culture in southern France, I would note that propositions for parliamentary aid for the olive crops have been made by the senator for Nice. He says that up to 1860 this was the most important product of these regions, and the crops were worth from 10,000,000 to 20,000,000 francs ($2,000,000 to $4,000,000, in round numbers). A gradual diminution has since occurred, until in 1899—a very bad year, it is true—the value of the crop was but 150,000 francs (about $30,000). The cause has been the ravages of the olive fly and the black blight. The senator complains that no concerted measures have been taken to combat the destruction of the olive plantations, and states that one obstacle is the high price of spraying machines, capable of spraying with economy liquid to a height of from 30 to 45 feet.

I think I have seen advertisements of American spraying machines, intended to reach the highest fruit trees, which cost a very moderate sum. If manufacturers of such articles will send me their catalogues and prices of all such appliances, I shall have them forwarded to those interested, with a view to introducing them into this market.—Harold S. Van Buren, Consul at Nice.

Hints on East Indian Trade.—I learn from reliable sources that among American and European firms catering for the East Indian trade, there has been noticeable of late a tendency to do business direct with the native importers. While this setting aside of the established commission houses at the seaports promises on the one hand an anvantage, in so far as a large business may be expected by dealing direct with the natives, it has on the other hand very serious drawbacks, owing to the fact that in the East Indies no law exists for the registration of firms, and it is often impossible to ascertain by what persons a concern is owned. Information regarding the standing of a native concern is of little value, as, if fraud be intended, the owner of the concern can say that he is only the agent for some other person.

American export houses should be careful in opening up business relations with native firms, especially up country, and should rather confine themselves to the profitable markets at the seaport towns. The bazaar at Bombay, it is reported, is open for a good many articles, but a careful study of the goods wanted is required; first-class products are not so much in demand as cheap and showy ones. If our people want to capture these markets, they should send shrewd and reliable persons to study the local wants, and then pack the goods as desired by the natives. German export houses do this very successfully.—Oliver J. D. Hughes, Consul at Coburg.

Trade Openings in the Transvaal.—Under date of June 12, 1901, Consul-General Guenther reports from Frankfort:

The Belgian consul at Johannesburg says that there will soon be openings for the sale of the following goods in the Transvaal: Axles of steel and iron for locomotives, railroad cars, and other vehicles; wagon springs and oil and grease boxes; all the various materials for narrow-gage railroads; implements for agriculture and forestry; also rolling cars for mines, drawbridges, etc.; hoists and hoisting machinery for mines, pumps, ventilators, and other mine appliances; cutlery of all kinds.

Mahogany in South America.—Consul-General Guenther writes from Frankfort, June 12, 1901:

German technical papers state that in Central and South America the revenues of many districts depend on the skill and activity of the mahogany hunters. Mahogany trees do not grow in groups; much less are there whole forests of them. They are scattered, usually concealed in thickets. It requires skill and experience to find them. To fell a tree involves the work of two men for a whole day. On account of a thick thorny growth near the base of the tree, a scaffold is erected around it, and above this, at a height of from 10 to 15 feet, the tree is cut, so that the best part is really lost. The felled tree is then freed of branches and hauled on a rough wagon by oxen to the nearest river, where rafts are made and floated down.

New Method for Producing Anæsthesia.—Consul-General Guenther reports from Frankfort, May 20, 1901:

A new method of producing anæsthesia was discussed at a recent meeting of the Medical Society of Berlin. Dr. Wohlgemuth has constructed an apparatus by which patients inhale chloroform mixed with oxygen. It has been tried by many prominent surgeons, with results that are reported as satisfactory, the disagreeable sensations being obviated.

German Device for Removing Slag from Grates.—Consul Warner writes from Leipzig, May 15, 1901, that according to the Leipziger Tageblatt, a new device for removing slag has been patented, by which the grate is lowered into the ash box or pit, a set of iron rods which fit into the spaces between the bars passing upward between them and knocking off any clinkers or slag which may have adhered to the bars of the grate.

Demand for Palms in Hungary.—Consul Chester writes from Budapest, May 14, 1901, that Mr. D. Schneider, a florist and manufacturer of artificial flowers of that city (VIII Józef Könft, 62), desires the names of firms in Florida exporting prepared palms, a stock of which Mr. Schneider keeps for ornamental purposes. The books of reference in the consulate give the names of manufacturers only, and the consul thinks that if a book giving the names of exporters of raw materials were sent him, it might aid in promoting trade.

Port Improvements at Caribe, Venezuela.—Consul Ellsworth, of Puerto Cabello, June 14, 1901, says that Señor Francisco B. Teran has secured a contract from the Venezuelan government to construct at the port of the River Caribe a wharf 30 meters (99.3 feet) long and 6 meters (19.7 feet) wide. The work must be begun within one year from date of contract and be completed within twelve months thereafter. In payment, the Consul adds, the government grants the contractor the exclusive right to the customs of the port of Caribe for a period of twenty-five years; at the end of this time, the wharf, with all its accessories, in good condition, is to pass into the hands of the government.

German Commercial Association in Japan.—Consul-General Guenther, of Frankfort, June 4, 1901, says:

A report from the German Consul-General at Yokohama states that the German merchants of Yokohama and Tokyo have formed an association for the purpose of promoting German commercial interests in Japan. The association will also act in conjunction with similar German bodies in eastern Asia and keep in touch with the East Asiatic Association of Hamburg. This new association has taken steps for the publication of a weekly newspaper in German. The German firms in Japan have guaranteed an annual amount of 6,000 yen ($3,008) for a period of three years.

INDEX TO ADVANCE SHEETS OF CONSULAR REPORTS.

No. 1099, July 29.—*United States Trade with Germany.—*New Lines of the Hamburg-American Steamship Company.—Commerce of Cyprus.

No. 1100, July 30.—Bauxite in New South Wales.—Match Trade in India.—*Mangoes in India.—*Metal Workers' School in Saxony.—*Trade opportunities in the Persian Gulf.

No. 1101, July 31.—Demand for Cotton Sheetings.—*Wagon Roads in Palestine.—*Exportation of Cereals from Turkey Prohibited.

No. 1102, August 1.—Diamonds in New South Wales.—Corundum Deposits of Canada.—Trade of Chile in 1900.

No. 1103, August 2.—*High Speed Electric Traction at Berlin.—*Trade of Peru in 1900.—*Labor Commission in Northern Italy.—*Strikes in British Columbia.—*Paraguay Export Company.

No. 1104, August 3.—Protection of Roads in China.—Patent Medicines in Austria.—Automobile Exposition in Hungary.—*Information Desired Concerning Charitable Work.—Turkish Merchant Marine.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

SELECTED FORMULÆ.

Private Recipes, by Alwin Engelhardt, in Neueste Erfindungen and Erfahrungen.

LILY OF THE VALLEY.

Extrait rose	200 grammes
Extrait vanilla	200 grammes
Extrait orange	800 grammes
Extrait jasmin	600 grammes
Extrait musk tincture	150 grammes
Neroli oil	10 grammes
Rose oil	6 grammes
Bitter almond oil	4 grammes
Cassia oil	5 grammes
Bergamot oil	6 grammes
Tonca beans essence	150 grammes
Linaloa oil	12 grammes
Spirit of wine (90 per cent)	3000 grammes

GUARDS BOUQUET.

Neroli extract	400 grammes
Orris root extract	600 grammes
Vanilla extract	400 grammes
Rose extract	900 grammes
Musk extract	200 grammes
Orange extract	500 grammes
Clove oil	6 grammes
Bergamot oil	5 grammes
Rose geranium oil	15 grammes

ORANGE.

Orange extract	1000 grammes
Jasmin extract	120 grammes
Orange flower water	30 grammes
Bergamot oil	8 grammes
Neroli oil	15 grammes
Musk tincture	10 grammes

PATCHOULY.

Rose extract	3000 grammes
Cassia extract	600 grammes
Tuberose extract	600 grammes
Jasmin extract	1200 grammes
Rose water	300 grammes
Civet tincture	20 grammes
Musk tincture	20 grammes
Patchouly oil	50 grammes
Rose oil	5 grammes
Geranium oil	10 grammes

SPRING FLOWERS.

Rose extract	500 grammes
Violet extract	500 grammes
Rose oil	5 grammes
Cassia extract	70 grammes
Bergamot oil	8 grammes
Amber essence	25 grammes

MIGNONETTE.

Extrait cassia	200 grammes
Extrait jasmin	200 grammes
Extrait tuberose	200 grammes
Extrait violet	900 grammes
Extrait rose	400 grammes
Extrait rose oil	2 grammes
Rosemary oil	6 grammes
Musk tincture	120 grammes
Geranium oil	5 grammes

LILAC.

Extrait jasmin	300 grammes
Extrait rose	300 grammes
Extrait vanilla	15 grammes
Extrait Peru balsam	5 grammes
Extrait orange	140 grammes
Extrait mignonette	100 grammes
Rose oil	2 grammes

COLD CREAM.

Melt at moderate heat—

White wax	100 grammes
Spermaceti	1000 grammes

then stir in

Almond oil	500 grammes
Rose water	260 grammes

and scent with

Bergamot oil	10 grammes
Geranium oil	5 grammes
Lemon oil	4 grammes

GLYCERIN CREAM.

Melt—

White wax	150 grammes

with

Almond oil	500 grammes

add while stirring

Glycerin	200 grammes

and scent with

Geranium oil	10 grammes
Rose oil	1 gramme

RICINUS CREAM.

Castor oil	500 grammes
White wax	100 grammes
Almond oil	150 grammes

Melt at moderate heat and scent with

Geranium oil	6 grammes
Lemon oil	5 grammes
Bergamot oil	10 grammes

Vaselin Saddle and Harness Paste.—

Vaseline oil, 0.875	30 pounds
Vaseline oil, 0.885	24 pounds
Amber resin	9 pounds
Palm oil soap	7 pounds
Ceresin wax	7 pounds

Method.—Melt the resin, soap and wax, then pour in the oils, and stir well. Before getting quite cold run out into the tins.

Violet Sachet.

Orris root	16 ounces.
Benzoin	2 ounces.
Essence of cassia	½ ounce.
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